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CONTENTS

	Page
World Population and Resources	1
Debye's Collected Papers. By Sir Eric Rideal, M.B.E., F.R.S.	4
The Sinews of Science. By Prof. L. Rosenhead, C.B.E., F.R.S.	4
Birds of West Africa. By Sir Landsborough Thomson, C.B., O.B.E.	5
Principles and Applications of Chromatography	5
Phytogeographical Writings of Sir Joseph Hooker. By Prof. Ronald Good	6
Nicolaus Steno, Seventeenth-Century Anatomist, Geologist and Ecclesiastic. By V. A. Eyles	8
Botany in the University of Glasgow: 250th Anniversary	10
Fundamentals of Colour Reproduction. By Dr. R. W. G. Hunt	12
Obituaries:	
Prof. K. N. Bahl. By Prof. A. C. Hardy, F.R.S.	16
Dr. R. S. Clay. By The Rev. W. L. Doughty	16
News and Views	17
Fifth International West African Conference. By Prof. L. Dudley Stamp, C.B.E.	21
The Golgi Apparatus: Symposium of the Royal Microscopical Society. By Dennis Lacy	21
The Immobilization of Mineral Nutrients in Tropical Soils	23
Tobacco Research Board of Southern Rhodesia: New Headquarters Station at Kutsaga. By Dr. F. A. Stinson	25
Industrial Research and Development in the United States	26
Cambridge Observatories: Report for 1953	26
Assay of Tritium-labelled Substances: a 'Combustion Bomb' Method of Preparation of Gas for Counting. By P. R. Payne and J. Done	27
Narcotics and Brain Respiration. By Dr. J. J. Ghosh and Prof. J. H. Quastel, F.R.S.	28
Letters to the Editors:	
Fractionation of Deoxyribonucleoprotein by Successive Extraction with Constant Salt Concentration.—J. A. Lucy and Prof. J. A. V. Butler	32
Effect of Hæm-linked and Other Ionizations on Hæmoprotein Reactions.—Dr. Philip George and Dr. G. I. H. Hanania	33
Biosynthesis of Hæmin in Soy-bean Nodule Homogenates.—Jonas E. Richmond, Dr. Kurt Salomon and S. Caplin	34
Hæmoglobin in *Heterakis gallinae*.—Prof. G. van Grembergen	35
Biological Value of Proteins as influenced by Dietary Vitamin B_{12}.—B. R. Baliga, S. Balakrishnan and Dr. R. Rajagopalan	35
Enzymatic Conversion of Salicylhydroxamic Acid to Salicylamide.—Prof. Julius Lowenthal	36
Effect of Posterior Pituitary Hormone on the Release of Adrenocorticotrophic Hormone.—Shinji Itoh and Akira Arimura	37
Oxidative Dissimilation of Glycerol studied with Variants of *Bacillus subtilis*.—Prof. J. M. Wiame, S. Bourgeois and R. Lambion	37
Isolation of *n*-Heptadecanoic Acid from Hydrogenated Mutton Fat.—R. P. Hansen, F. B. Shorland and Dr. N. J. Cooke	39
Short-range Electrical Forces between Charged Colloid Particles.—Dr. D. M. C. MacEwan	39
X-Ray and Differential Thermal Studies of some Indian Montmorillonites.—A. K. Bose and Purnima Sengupta	40
Heat Transfer in Pulsating Flow.—Prof. H. A. Havemann and N. N. Narayan Rao	41
Ageing of Quartz Crystal Vibrators.—H. T. Mitchell	41
Cadmium in Sea-water.—J. B. Mullin and Dr. J. P. Riley	42
Succinoxidase Activity of the Flight Muscles of the Wasp, *Sceliphron cementarium*.—Prof. Sol Kramer	43
Thermal Reactions of Kenya Cattle vaccinated with Lapinized Rinderpest Virus.—G. R. Scott	44
A Polarographic Method for the determination of the Gamma Isomer of Benzene Hexachloride in Cattle Dips.—G. W. Walker	44
Isolation from the Lower Respiratory Tract of Chickens of Bacteria administered by Mouth.—H. Williams Smith	45
Tape for Microsectioning of Very Large, Hard or Brittle Specimens.—Prof. Axel Palmgren	46
Zoological Nomenclature.—Francis Hemming, C.M.G., C.B.E.	46

WORLD POPULATION AND RESOURCES

IT is generally conceded that a great effort will be required to supply the world's increasing population with adequate food, fuel and raw materials during the next half-century; the complexity, magnitude and seriousness of that problem is well stated in simple terms in a broadsheet (No. 362) dated April 26, issued by Political and Economic Planning. Prepared essentially as a contribution to the World Population Conference in Rome, the broadsheet formulates the main issues in a way that every citizen can understand, and its summary and conclusions should contribute also to a much more intelligent appreciation of the value and limitations of the Technical Assistance Programme of the United Nations, the Colombo Plan and the projects promoted by the United States in accordance with the Point Four Plan than is frequently apparent in discussions in Parliament and elsewhere. The fact that it limits its survey to no more than A.D. 1980 may well help to drive home the urgency of the situation.

The situation to which Prof. A. V. Hill referred in his presidential address at Belfast to the British Association is here presented, not as a dilemma, ethical or otherwise, but as a problem demanding imperatively constructive thought and concerted action. P E P points out that during the past two hundred and fifty years medical science has been developing gradually in Western countries, and its effect on the population has been gradual; corresponding reductions in birth-rates have kept the repercussions within bounds. Now the conquest of disease is making its impact felt much more rapidly on the much larger non-European populations. These are expanding on such an enormous scale that it is possible that the world increase during 1950–80 may about equal the entire world population in 1900.

The reception of Prof. Hill's address two years ago would in itself seem to justify the contention by P E P that even informed opinion has scarcely begun to appreciate the magnitude of the economic, social and political problems which are being generated by a current net increase of more than 70,000 persons a day that is still tending to rise. Such books as "Four Thousand Million Mouths" and "Soil and Civilization" only direct attention to one facet of the problems, and probably the only one to which the ordinary citizen has given even passing attention. The most pressing of these problems is, as P E P points out, that of finding food, materials, fuel and power to take care of the vast increase and at the same time to enable reasonable improvements to be made in the standards of life of the large numbers at present below a decent minimum level. Whether simultaneously it will be possible to realize some of the existing expectations for rising standards of life in the more advanced countries is certainly open to question, and likely to depend on conditions not yet sufficiently clearly understood: it can scarcely be taken for granted, as the broadsheet seems to imply.

The examination of the present position presented by P E P suggests that the growth of world food supplies holds a precarious and narrow lead over the growth of world population. The practical problem, however, is for each country to feed itself, since for most countries imports offer no regular relief to home production. The implication of this view for the United Kingdom is reinforced, moreover, by a firm warning against over-optimistic expectations of large increases in agricultural output in particular areas compared with that long maintained by the more agriculturally advanced and favourably placed food-producing countries. With about sixteen per cent of the land area of the world, the U.S.S.R. still has difficulty in feeding its eight per cent of the world population.

In many of the worst-fed countries, the rate of increase in population is above the average and the rate of expansion of food supply only average or below the average. These countries are also faced by exceedingly difficult economic problems, especially in regard to provision of essential capital and the development of industry and public services. These factors have already damped the optimism with which the Colombo Plan was at first regarded, and the report of the Indian Planning Commission which Prof. Hill quoted has also prompted a more realistic view of the situation. The analysis of the highest rates of increase in the production of food to be attained in the most favourable circumstances and of foreseeable technical improvements as given in the P E P broadsheet discloses no sound basis for the view that production will more or less automatically keep pace with the needs of growing population. Indeed, in the absence of a much more rapid reduction in birth-rates than is at present in sight, it is obvious that the increasing control of disease in the less developed countries is likely to lead to a further expansion in population which will render this most improbable.

The broadsheet does not enter into a discussion of the situation in regard to fuel and power supplies and raw materials, or the demand on the world's economy, for example, that is entailed in the provision of the fertilizers required for the increased production of wheat and other foodstuffs. It notes that implication, for the group which prepared the broadsheet considered also the possibilities of creating resources without calling on any material at present of economic value or likely to become scarce. Its extensive inquiries, however, disclosed no such developments affecting foodstuffs likely to prove of first-rate importance during the next thirty years.

In this respect the broadsheet is less optimistic than Sir Harold Hartley was in his recent Fawley Foundation Lecture (*Nature*, June 12, p. 1126); but it is only fair to add that the broadsheet attempts no more than a presentation of the broad outlines of a problem to be discussed more fully in a subsequent report, which will also review the relationship to population of supplies of fuel and power and of raw materials. It aims at stimulating the searching, informed and dispassionate discussion of the facts in all countries and among all shades of opinion, with the view of agreeing on a diagnosis. This is the immediate need, for only a few governments, notably that of India, have shown a lively awareness of their own problems of matching resources with population.

So far as the broadsheet touches on the long-term outlook for supplies of raw materials, fuel and power, it is quite as realistic as Sir Harold, and though less reassuring it does not anticipate that unmanageable difficulties will be encountered in these fields in the near future. Apart from its warning about the limits set to the general achievement of the best rates of increased production of food in particular areas, and of the danger that the rate of increase in population may itself increase with the rate of increase of food production, the broadsheet is of real value for the way in which it indicates, even more clearly than did Sir Harold Hartley, that we are faced with a series of competitive—not complementary—demands and problems. The four unsolved problems are: increasing existing food production sufficiently to supply extra suitable foods for the annual increase in population; providing suitable foods for the undernourished section in the existing population; producing without detriment to food supply sufficient raw materials, fuel and power to enable the increased world population to earn its living and add to its wealth; and ensuring either access for the increased population to areas where extra food and raw materials can be produced, or the transport and distribution of an increased supply of food and raw materials to countries deficient in home supplies on terms which they are able to pay.

It is this note of realism that requires sounding to-day. Sir Harold Hartley, in his Fawley Foundation Lecture, and also the P E P broadsheet, admit that possibly entirely novel methods discovered as a result of biochemical, microbiological or photochemical research may offer an important contribution to increased food production without the strain on limited resources which the expansion of conventional agriculture would involve. There, however, he reminds us of the importance of an ecological approach. The careless disturbance of the balance of Nature may have unforeseen and serious consequences. If the dangers to mankind depicted with some journalistic licence in Jungk's "To-morrow is Already Here" are to be avoided, much more serious ecological research will be required in forestry, agriculture and horticulture, pest control and animal health and nutrition, nor is such research likely to bring quick returns.

Meanwhile, as P E P points out, no serious evidence has been produced to show that there is extra cultivable land anywhere of sufficient extent and quality and capable of sufficiently rapid development to make any worth-while contribution to the urgent task of feeding the world's daily increment of population; nor can that increment be fed on generalizations or on hopes of what might be done assuming levels of capital and equipment, technical skill, education and management which are not, and are unlikely to become, available. Much can be done fairly quickly to improve yields and output from existing farmlands through better seed and livestock,

better farming, more and improved fertilizers, simple but more effective equipment, more double cropping in suitable climates, and through reducing waste. Unfortunately, the very countries where the urgency of achieving these improvements is greatest and where the opportunities are most obvious are also those in which deficiencies in education, adaptability, capital, equipment, communications and physical vigour are most serious.

In directing attention to the limitations which such factors place on technical advances and in pointing to the contributions which can come from better education and the increased vigour arising from improved health, as well as from such capital developments as irrigation and drainage, P E P in this broadsheet tends to correct the materialistic emphasis and outlook of Sir Harold's lecture. Sir Harold seems to overlook not only the importance of this factor of education but also the demands which are made on man himself. The self-control which is demanded—particularly in those areas where population is increasing most rapidly and malnutrition is most rife—in order that the greater productivity which the wise use of science could bring is to keep pace with the needs of an increasing population is unlikely to come unless the campaign against want is accompanied by a no less vigorous campaign against ignorance. Nor is the driving force for such a campaign to be found in any view of man that takes account solely of his physical or material needs.

In Asia and Africa, as in the West, man's hope of a richer and fuller life in any sense rests ultimately on a worthy view of man himself. It is true that, in the backward areas of the world, men can only rise to their full stature and make free judgments between right and wrong when science and industry have removed want and malnutrition and the ignorance which is largely responsible for these conditions. It is true also that below a certain level of physical existence few men can have any apprehension of moral or spiritual values of life, and it is not materialistic to be concerned with devising ways and means whereby ordinary men and women may be raised above this animal level of existence.

Nevertheless, the problem is not a purely physical or materialistic one. Primarily, it is an intellectual problem—a challenge to man's intellect as well as to his self-control. Education, as already indicated, is one of its most important aspects, and this is true at the primary or secondary school level, in the colleges, in the technical colleges, and at the university level, within and without the walls. The solution of this problem involves much more than the right use of science and technology for the efficient use of man's material resources, the appropriate training of a sufficient number of scientists and technologists and technicians, and attracting able pupils to pursue such careers. It equally depends on using the new means of education which science has provided to train men and women to understand how to make use of the possibilities latent in science and technology, and the dangers inherent in the abuse of those possibilities, and to appreciate what is demanded in the way of co-operation and self-discipline in order that society may enjoy the benefits which are within its reach. It implies also that the training of the embryo scientist or technologist shall enable him to understand better the ordinary man and woman whose needs his work will serve, and whose lives will be affected by its results.

Neither education in science alone, nor education without science, will suffice, and herein lies the critical importance of an adequate number of science teachers of high quality and character. That is indeed a first step towards providing means for the solution of the hard technical and political problems that are involved in the utilization and distribution of the world's resources among its expanding population. It is an important contribution towards the taking of the right decisions and the implementation of the policies they imply, once those solutions have been found. Only education can overcome the refusal to face facts which lies at the root of the perennial difficulty of relating knowledge to action; and in order to succeed, such an education must impart at least some understanding of the outlook and method of science.

The importance of education in this connexion is well seen in the symposium of papers on Technical Assistance Programmes contributed to a recent issue (March 1954) of the *Bulletin of the Atomic Scientists*. It is also apparent in yet another broadsheet (No. 363), in which Political and Economic Planning, discussing the use of private capital for under-developed areas, shows how serious has been the fall in the flow of such capital to these countries, due largely to the ignorance and misunderstandings which education could help to remove. The prospects of stimulating either the flow of badly needed private capital or increasing the supply of technical and managerial experience which accompanies it are slender indeed without deeper understanding on all sides.

The problem of matching the earth's resources with the needs of its expanding population is fundamentally an intellectual problem—a challenge to man's capacity to think, to improvize and to organize. If he will make the effort, there is no present reason for believing that a solution cannot be found which will enable the world's population to be fed adequately, and increasing control maintained over the pests and diseases which take toll of human life and energy, crops and animal life, while ensuring also adequate supplies of materials for industry. But there will be a price demanded in individual self-control, as in that of communities; and it is not on education alone that we can rely to ensure that the price is paid. Whether, in fact, the nations, and the communities of which a nation is made up, will pay that price and renounce the prejudices and the customs and ways of life that endanger the efficient utilization and effective distribution of the world's resources, will not depend solely on whether an adequate supply of scientists, technologists, technicians, science teachers, and the like is forthcoming, or even on a clear apprehension on the part of the population generally of what science is and how it works. The problem of relating action to knowledge rather than

prejudice is not simply an intellectual issue: it is also a moral issue, in the sense that only a worthy view of man can compel the action, and induce men and women to accept the sacrifices, which in one way or another will be demanded of the advanced and also of the more backward areas of the world.

Meanwhile, in Great Britain, no political party seems prepared to deal with the problem of education on realistic lines or to court the unpopularity which might be involved thereby. Trades unions seek to resist changes in practice that would eliminate waste. Even in education and social policy there is much that encourages the increase of the less educable or adaptable types, and tends to undermine incentive and slacken the will to work. Even some lines of research seem to be pursued rather as an excuse for delaying action on already known but unpalatable facts. As Sir Charles Darwin has commented, "the policy of paying most attention to the inferior types is the most inefficient way possible of achieving the perfectibility of the human race". When all regard is had to the possibilities of those advances in knowledge which such researches as Sir Harold Hartley suggested might bring, it should be remembered that mankind has already much knowledge which, if used effectively, could go far towards improving the balance between the demands of an increasing population and world resources. Nor will any fresh largesse which science may confer remove the fundamental need for courage and honesty in the use of present knowledge.

DEBYE'S COLLECTED PAPERS

The Collected Papers of Peter J. W. Debye

Pp. xxii+700. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1954.) 9.50 dollars.

TO celebrate the seventieth birthday of Prof. Peter Debye, this volume containing a selection of his classical papers has appeared. No one during the past forty years has made so many significant contributions to modern physical chemistry as has Prof. Debye: his name will always be associated with such topics as X-ray scattering, the theory of strong electrolytes, dipole moments and, during more recent years, with the scattering of light by colloidal solutions.

In this book his classical papers on these topics are collected together under their respective headings, together with a number of miscellaneous communications, including the important one on the specific heat of solids. While the book is an important one for purposes of reference, it is most valuable in that it gives us a glimpse of the methods of attack adopted by one who, trained as a mathematician, became in turn professor of theoretical then of experimental physics and finally professor of chemistry, in which subject he received the Nobel Prize. Grouping of the papers in subjects in the volume permits us to follow the progress by which the Debye–Scherrer method of X-ray examination of powders was developed and the subsequent excursions into the exploration of liquids and gases. It is interesting to note that Debye gave an independent theory of the Compton effect, but a little later than Compton himself. The section on electrolytes is introduced by the well-known paper of Debye and Hückel, which classical paper is the basis of the present-day concepts concerning electrolytes. During the Second World War the United States Government was interested in developing the synthetic rubber industry, and Debye became interested in methods of examination of macromolecular solutions. His interest in the scattering of X-rays naturally led him to investigate the applicability of Einstein's theory of light scattering to randomly coiled molecules, and as a result a method not only for the absolute determination of the weight-average molecular weights but also of the spatial extension of the macromolecules in solution was developed, probably the most valuable tool presented to workers in the field of polymers.

The volume has, as preface, a brief account of the life of Debye, and this is followed by brief surveys of the various topics by H. Mark on X-rays and light-scattering, C. P. Smyth on dipole moments and R. M. Fuoss on the papers on electrolytes. Papers originally in the German language have been translated into English. Perhaps this is the most unsatisfactory feature of the volume: Debye's papers both in German and in English are remarkably lucid and clearly written; but the translations do not do the author justice.

ERIC K. RIDEAL

THE SINEWS OF SCIENCE

Mathematics in Action

By Prof. O. G. Sutton. Pp. viii+226. (London: G. Bell and Sons, Ltd., 1954.) 16s. net.

PROF. O. G. SUTTON is to be congratulated on his book "Mathematics in Action". The publisher's simple comment on the jacket that "the book is a straight-forward account of applied mathematics and its influence on modern ideas concerning that nature of the physical universe" is a bald understatement. The story which the author tells illumines the essential features of the scientific method—the search for basic principles hidden within experimental results, and the development of pathways from basic principles to new experiments and speculations.

The writing is simple and elegant, and not without evidence of a dry humour; the author has a flair for simple exposition and has steered a masterly course between the Scylla of over-simplification and the Charybdis of over-elaboration. The book itself is a pleasure to hold and to read; the illustrations have been chosen with care and have been drawn with sympathetic understanding.

In most books on experimental physics one can scarcely see the wood for the trees. Most books on applied mathematics, on the other hand, model themselves on Euclid; after a token genuflexion in the direction of experimental physics, they develop their accounts as a series of deductions from a number of stated general principles. Contact with the world of reality is usually lost, at each new topic, after one or two introductory paragraphs. It is these brief paragraphs which Prof. Sutton has moulded, and expanded, into a book of about 225 pages. "Mathematics in Action" should be of considerable value to young mathematicians, physicists and engineers, in the upper forms of secondary schools, and also in technical colleges and universities. It should be an

excellent source-book of ideas for teachers of science, and also for those students of the interpretative humanities who wish to gain some knowledge of how the ideas of physicists and engineers have been made more precise and more powerful through formulation in terms of mathematics. In passing, the book shows how mathematics in action has stimulated both the experimenter and the mathematician.

As the narrative unfolds, the author gives a very personal account of what is meant by 'theory' in physics and mathematics. The way in which ideas underlying some of the theories have evolved is briefly sketched. Empirical formulæ lead to mathematical abstractions; the world of reality leads to the worlds of the mathematician, and these lead back again to the world of reality. The most remarkable thing about this process is that there should be any correlation at all between the two types of world—but experience has shown that there is. One of the really important problems of philosophy is to explain this connexion.

Prof. Sutton traces the development of the ideas underlying classical physics and comments: "It is a strange thought that a few symbols, 'meaningless marks on paper', have contributed so much to the shape of life as we know it to-day. A mediæval scholar, awakening in our world, would recognize such symbols as spells, magic formulæ which when properly pronounced confer power over the forces of Nature".

To lend point to his comments, Prof. Sutton talks about arithmetic, algebra, complex numbers, calculus, etc.—the tools of the mathematician's trade. Then, in the tradition of the English method of teaching mathematics and physics, he gives a series of examples, which in this case are illustrations from ballistics, waves, the problems of flight, statistics and meteorology. His examples are beautiful little essays. The topics which are discussed are all taken from subjects in which Prof. Sutton has had to work professionally from time to time, and they give some indication of the width of his interests and powers. The book deserves to be read by many people.

L. ROSENHEAD

BIRDS OF WEST AFRICA

The Birds of West and Equatorial Africa

By Dr. David Armitage Bannerman. Vol. 1: Struthionidae to Picidae. Pp. xiii+796+plates 1–37. Vol. 2: Eurylaemidae to Ploceidae. Pp. viii+797–1526+plates 38–54. (Edinburgh and London: Oliver and Boyd, Ltd., 1953.) 2 volumes £6 6*s*. net.

THE author's "Birds of Tropical West Africa" in eight volumes (1928–51) will inevitably be known in future as 'the large Bannerman'. It must remain the basic work, indispensable for many purposes; but it is too bulky to be readily portable, and the earlier volumes are obtainable only with difficulty and at a high price. Now we have 'the small Bannerman' as well, complete in two volumes, and its availability and more compact form will make it most welcome to the field observer. It should be of great help to the latter, and it should stimulate further interest in the subject. There are still many gaps in knowledge which a resident in West Africa can take part in filling; and one may well follow the rule that, if an indubitable observation is 'not according to Bannerman', it is worthy of record.

The new work is essentially a condensation of the older, although the text has been wholly rewritten, and as a condensation it must be judged. The reduction in length has been achieved largely by the omission of detailed technical descriptions, synonymies, references, and separate treatment of geographical races; none of these will be missed by the field observer. On the other hand, the great abbreviation in the account of habits is less easily accepted, as it is especially in this respect that there are opportunities for filling gaps in knowledge, if one can be sure where they exist.

Rewriting has involved distribution to the proper heads of all the addenda to the larger work which were published at its end. The new book professes to be up to date as at the close of 1950, when the manuscript was completed; but one notes that some observations recorded as late as 1952 have, in fact, found a place. Apart from the repetition of the useful identification keys from the larger work, the book consists of the standard information relating to each species. One misses a more general section, giving a comprehensive account of the characteristics of the area, which ranges from arid desert to tropical rain-forest and is traversed from its highlands to its coasts by great rivers.

One welcomes again many of the excellent coloured plates from the earlier work, with a few newcomers, as well as numerous black-and-white illustrations. Turning the pages in the less sunnier clime of Great Britain, one recalls many a characteristic sight—the aerobatics of the brilliantly coloured Abyssinian roller, the trees loaded with the nests of weaver birds, the restless parties of piapiacs on the Borassus palms, the egrets among the grazing sheep, and on some up-river sandbank the crocodile bird of which Herodotus wrote.

LANDSBOROUGH THOMSON

PRINCIPLES AND APPLICATIONS OF CHROMATOGRAPHY

Chromatography

A Review of Principles and Applications. By Edgar Lederer and Michael Lederer. Pp. xviii+460. (Amsterdam: Elsevier Publishing Company; London: Cleaver-Hume Press, Ltd., 1953.) 60*s*.

CHROMATOGRAPHY has grown out of all recognition during the past ten years. Yet, although a number of excellent monographs have recently appeared which deal with special aspects of the subject, none has dealt with the subject as a whole. The publication of this book is therefore timely: the authors have brought together information from a formidably vast field and presented it attractively. They have themselves made distinguished contributions to chromatography, and therefore have a first-hand knowledge of much that they have written. The book is divided into five main sections. The first three deal with the general principles and techniques of the three main types of chromatogram, namely, adsorption, ion exchange and partition. Theoretical aspects are here treated simply but adequately for the purposes of the book. The fourth section is concerned with the applications of these methods to organic substances, and largely consists of chapters each devoted to a particular class. The fifth section deals with the inorganic field and is probably the most comprehensive account of this subject that has yet appeared. Finally, there

follows a list of references and addenda to the various chapters which brings the literature survey up to the end of 1952. The completeness of this section is an outstanding feature.

It is remarkable how well the authors have succeeded, in a book of ordinary dimensions, in dealing so adequately with such a wide subject. The emphasis has rightly been on the newer methods, but important aspects of the older have not been ignored. There are many valuable features. For example, more than ninety tables of R_F values are given, which cover many hundreds of substances. There are many tables which give useful information at a glance, and the book is generously illustrated with diagrams and photographs of apparatus, chromatograms, elution curves, and so on. It is an achievement of the book that many of the methods are sufficiently well described to enable one to carry them out in the laboratory without having to delve through a mountain of literature beforehand. Division of the text into many subsections has made for attractiveness in presentation. A word of tribute, too, must be paid to Dr. A. T. James, who translated part of the book from the original French into good English.

In a book which provides so much information, one feels diffident in suggesting that a little more could have been given in one or two places. There might, for example, have been provided representative chemical formulæ for all the numerous classes of organic compounds—for who but the final-year chemistry honours student remembers them all? Perhaps a more detailed explanation could have been given of how the identification of the products of partial hydrolysis of complex substances helps to provide a picture of the whole structure, and more about how some of the reagents (ninhydrin, for example) used in paper chromatography react with the substances for which they are used. There might be some justification, in view of the correspondence in *Nature* (which is cited), to have included in the historical section some account of the contributions to chromatography made by British contemporaries of Tswett. It would have been helpful if the references, which are arranged in alphabetical order, were each followed by the page number in the text.

These are, however, minor criticisms. The authors and publishers are to be congratulated on the production of an attractive book of outstanding importance. It should be in the hands of those who use chromatographic methods, those who expect to use them and those who ought to use them—that is, every chemist and biochemist.

PHYTOGEOGRAPHICAL WRITINGS OF SIR JOSEPH HOOKER

Pioneer Plant Geography

The Phytogeographical Researches of Sir Joseph Dalton Hooker. By Dr. W. B. Turrill. (Lotsya—A Biological Miscellany—Volume 4.) Pp. xii+267+21 plates. (The Hague: Martinus Nijhoff, 1953.) 19 guilders.

RARELY can Fortune have showered so many of her favours on a botanist as she did on Sir Joseph Dalton Hooker, and seldom can there have been a botanist more fitted to make the most of them. The son of Sir William Jackson Hooker, he was born in the botanical purple, and his father's distinguished career afforded him quite exceptional opportunities for his own scientific work. But his time was also propitious; born in 1817 and living until 1911, his life almost exactly spanned the longest and most complete period of tranquillity, freedom from distraction, and material prosperity that Great Britain has ever known, while his birth made him of such an age that he rode the rising tide of scientific progress at its flood and became, almost inescapably, a foundation member of the new biology. But, above all, Fortune endowed him with qualities of mind and character which enabled him to profit from all these circumstances. Fate offered him a giant's place, and he was big enough to fill it.

As with pioneers in many other walks of life, it fell to Joseph Hooker to say, for the first time, many fundamentally important things about his subject. Nowhere is this more obvious than in his phytogeographical writings, and Dr. W. B. Turrill has therefore done a very worth-while service in reminding us again of their more important passages. It is all too easy to think of such early work only in the idiom of to-day and to forget the part it has played in forging the ideas which now we think of as our own.

Some readers will doubtless be most interested in those extracts which reveal Hooker's attitude towards Darwinism and his gradual, though not very convincing, assimilation of it; but it is with plant geography that Dr. Turrill's book is almost wholly concerned. One's first feeling here is astonishment that so much was known so early in Hooker's career, and some slight chagrin that the advance since then has not been greater; but this is, for many reasons, rather unjust, although the fact seems to remain that only in the realm of palæogeography have we really passed beyond Hooker's comprehension. Many of the problems which troubled him are the problems which still perplex us, very notable among them being that of the way in which the oceanic islands and more isolated mountains of the world have become populated. These are still, as they were in his day, among the most crucial issues of plant geography.

"Pioneer Plant Geography" in the main takes the form of a series of chapters arranged in a formal geographical sequence, each consisting of long extracts from the relevant writings of Hooker, and a summary, by Dr. Turrill, of subsequent work on the same matters. The book is pleasantly produced, and there is a useful bibliography. In total it contains a great deal of information, some of it not easily come by elsewhere, and will certainly become an important source book for plant-geographers. At the same time, it does not conceal some of the exceptional difficulties inherent in a book of this sort. Of these only the author himself can be fully aware, and one hesitates, therefore, to comment on his procedure; but many will, perhaps, feel that Dr. Turrill's decision to abandon the chronological approach was an unfortunate one, since it not only threw away the most potent source of continuity in the narrative, but also deprived the reader of any opportunity of following the development of Hooker's personality and science. In consequence of this the book is somewhat lifeless, which, bearing in mind its subject, is a pity. It is also a little unfortunate that, owing to this geographical arrangement of the book, it first presents the least satisfactory of Hooker's geographical writings and leaves the consideration of his most classic (and earliest) memoirs to the end.

Ronald Good

Algebraic Geometry

By Solomon Lefschetz. (Princeton Mathematical Series.) Pp. ix+233. (Princeton: Princeton University Press; London: Oxford University Press, 1953.) 30*s*. net.

Ideal Theory

By D. G. Northcott. (Cambridge Tracts in Mathematics and Mathematical Physics No. 42.) Pp. viii+111. (Cambridge: At the University Press, 1953.) 12*s*. 6*d*. net.

IN the volume "Algebraic Geometry", Prof. S. Lefschetz has presented, in amplified form, his lecture notes of pre-war Princeton days. A concentrated account is given in the first three chapters of the algebraic treatment of the subject. Chapter 4, on formal power series, provides a bridge linking this with the analytical treatment. In this chapter, the theories of algebroid varieties and local rings are treated briefly and applied to a study of the local properties of algebraic varieties. Four chapters are then given to the theory of algebraic curves, and this work provides examples of the preceding general theory. The final chapter treats the theory of systems of curves on a surface.

Prof. Lefschetz has certainly dealt with the 'core' of the subject, but it is a pity that the account is so brief and concentrated. It is difficult to escape the conclusion that the book is a summary rather than an exposition. The treatment in one of the main chapters (4) is "admittedly sketchy and often without proofs", and in several places it is necessary to refer the reader to other books or journals for a more detailed account. This fragmentation in the presentation of information seems to be a feature of many contemporary publications; but the publishing houses rather than the authors probably have more to answer for in this matter.

In "Ideal Theory" we have an excellent account of a subject which has developed with a burst in recent years. It is easily the most important advance in commutative algebra for a generation; and the motive for this development has come from the need of algebraic geometers for a sharper and more powerful tool with which to examine the foundations of the subject. Prof. D. G. Northcott has written a very clear self-contained account, and has emphasized the algebraic and the analytic theory of local rings, the subject-matter of which has only emerged very recently. L. S. GODDARD

Principles of Radar

By Members of the Staff of the Radar School, Massachusetts Institute of Technology. Third edition, by Prof. J. Francis Reintjes and Godfrey T. Coate. (A publication of the Technology Press, Massachusetts Institute of Technology.) Pp. xv+986. (London: McGraw-Hill Publishing Co., Ltd., 1953.) 55*s*. 6*d*.

ALTHOUGH this volume is described as the "third edition", it is in fact the first British publication of the work in normal printed format. In its original form, it was in duplicated typescript, prepared by members of the staff of the Massachusetts Institute of Technology and issued as a classified document in 1944 to students of the Institute's Radar School. An extensive revision of the text was carried out before the material was released for general publication.

The book is essentially a detailed descriptive treatment of the technique of radar, with particular reference to the use and operation of radar installations on wave-lengths of between 1 and 30 cm. (frequencies of 30,000–1,000 Mc./s.). No mathematics beyond trigonometry and simple differentiation and integration are used; and the text is very clearly presented together with 650 diagrams, many of which are of exceptional quality and interest. The book may be recommended as an encyclopædic work of reference for all students, scientific workers and engineers engaged in this field; and users will be greatly indebted to the small band of experts responsible for the assimilation and collection in a single volume of a large mass of technical information and experience.

Fields and Waves in Modern Radio

By Simon Ramo and Prof. John R. Whinnery. Second edition. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1953.) 70*s*. net.

THE inclusion in this edition of a chapter on microwave networks is the main change from the first edition. Introductory chapters on oscillations and electric and magnetic fields provide the basic ground for the formulation of Maxwell's equations. Circuit concepts and high-frequency effects are then developed, and lead to a study of wave propagation in guides and along transmission lines. The final chapter on radiation completes the physical picture derived from earlier chapters.

Though written mainly for engineers, there is a good deal of common ground here for the physicist. The lucidity, directness of approach, and skill in presentation make this a most valuable book on electromagnetic theory. L. JACOB

Inorganic Chemistry

A Text-Book for Advanced Students. By Dr. E. de Barry Barnett and Dr. C. L. Wilson. Pp. xiv+512. (London, New York and Toronto: Longmans, Green and Co., Ltd., 1953.) 35*s*. net.

THIS book is intended for students who have an elementary knowledge of inorganic and physical chemistry, and many common elements and compounds are only mentioned as "too familiar to require description". The arrangement is based on a particular periodic table, and hence many less familiar elements appear before the commoner members of their groups. The old-fashioned name "first short period" is used, though the periodic table on p. 6 shows this to be the second.

The book begins with a short discussion of nomenclature, then deals with the classification of the elements and the periodic law, the determination of atomic weights, natural radioactivity, artificial atomic breakdown, isotopes, the structure of atoms and valency, stereochemistry and crystal structure. After three pages on ore-dressing, the individual elements, beginning with the inert gases, are dealt with, the rarer elements being, of course, included. Special topics such as the hydrides of boron, the metal carbonyls, peracids and the silicates are discussed; but the treatment of polyacids is unsatisfactory, and there are surprising omissions.

Attention is given to industrial processes, and use is made of official publications on those developed in Germany. Brief, but useful, notes on analytical chemistry are given. There are some references to literature. The book contains information not easily found elsewhere and is likely to be useful to students and teachers.

NICOLAUS STENO, SEVENTEENTH-CENTURY ANATOMIST, GEOLOGIST AND ECCLESIASTIC

NICOLAUS STENO (Niels Steensen) not only ranks as one of Denmark's greatest men of science but also occupies a distinguished place within the larger group of naturalists whose activities brought about the scientific revolution in Europe that marks the close of the seventeenth century. In addition, he played a prominent part in the religious life of the period. Not surprisingly, therefore, his life and work have been much studied, particularly by his own countrymen, and their latest contribution to these studies is a record of all Steno's surviving correspondence, both scientific and theological. This occupies two large quarto volumes, which have been edited by Father Gustav Scherz, of Copenhagen, assisted by Joanne Raeder*. Much of the literature about Steno is in the Danish language, or is contained in publications not easily accessible to British readers. An appreciation of the value of his letters depends on some knowledge of his achievements, so that a brief account of his remarkable career may not be out of place here. It is based mainly on the account, written in English, by Prof. Vilhelm Maar, of Copenhagen[1].

Steno was born in Copenhagen in 1638, and commenced to study in the University of Copenhagen at the age of eighteen. One of his teachers was the famous anatomist, Thomas Bartholin, a fact that doubtless influenced the course of his career. After pursuing a medical course in Copenhagen, which was interrupted by a war with Sweden, he followed the usual custom of the times and travelled abroad, to continue his studies at foreign universities. He went first to Amsterdam, and it was here, in 1660, that he made his first important discovery, the recognition of the parotid duct (ductus Stenonianus); there also began a friendship with the naturalist Jan Swammerdam, that continued throughout the latter's lifetime. After four months at Amsterdam, Steno moved on to Leyden, where he remained four years, studying under van Horne and Franciscus Sylvius. He had as a fellow student at Leyden Sir Robert Sibbald, the Scottish physician and naturalist, who records that Steno "dissected in my chamber sometymes, and showed me there, the ductus salivalis superior, he had discovered"[2]. In Holland, Steno gained general admiration, not only for his skill as a dissector and for his capacity for making new observations and drawing sound conclusions therefrom, but also for his pleasant and modest personality. At this time he met, among other well-known men, Benedict Spinoza. His intellectual interests widened, and he studied languages, mathematics and religion. He was now free to enter into discussions with members of the Roman Catholic Church, which had not been the case in Lutheran Denmark. His inclination towards mathematics, and particularly geometry, is reflected, later on, in his method of presenting the results of his anatomical and geological researches.

* Nicolai Stenonis: Epistolæ et Epistolæ ad eum Datæ. (Quas cum Procemio ac notis Germanice Scriptis.) Editit Gustav Scherz, adjuvante Joanne Raeder. Vol. 1: Pp. xxxii+480. Vol. 2: Pp. xii+481–1028. (Kjøbenhavn: Nyt Nordisk Forlag, Arnold Busck; Freiburg i Br.: Verlag Herder, 1952.) 175 Dan. Kr., or 105 D.M.

Family affairs compelled a return to Copenhagen in 1664. The reputation he had by then established as an anatomist would have justified an appointment as professor in the University, but this was not made. He therefore left Denmark in the same year, proceeding this time to Paris. He had letters of introduction to a well-known patron of the sciences in that city, Melchisédec Thévenot, who received him as a guest. French scientists were accustomed to meet for discussions in Thévenot's house, and it was here that Steno delivered his famous discourse on the anatomy and physiology of the brain[3].

Steno spent nearly a year in France, during which time he visited other centres of learning. In Montpellier he met two British naturalists, John Ray and Martin Lister. It is recorded that Ray was present when Steno dissected an ox's head and demonstrated the existence of the 'ductus salivaris'[4]; and Lister describes his meeting in the following terms: "I had ye honour to assist att an Anatomie Lecteur on some particular dissections and demonstrations made by Mr Steno ye Dane himself in my Lord of Ailesburys cabinet. the demonstrations were neat and clever wherein I much [? most] admired ye ingenuitie and great modestie of ye person. . . . Afterwards I visited Mr Steno whom I found infinitely taking and agreeable in Conversation and I observed in him very much ye Galant and honest man as ye french say, as well as of ye schollar"[5]. Steno possibly met also Dr. William Croone, first secretary of the Royal Society, at Montpellier. A little later on he addressed a letter on the salamander to Croone, which was published in the *Philosophical Transactions* of the Society, in 1667[6].

From France Steno passed on to Florence, arriving in the summer of 1665. Soon the Grand Duke Ferdinand II of Tuscany attached him to his court, and thereafter encouraged him in every way to continue his scientific investigations. Ferdinand and his brother Leopold were leading spirits in the Accademia del Cimento, and in Florence Steno moved in the same circle as the members of the Accademia, meeting, among others, Vincenzo Viviani, pupil and biographer of Galileo, and the naturalist Francesco Redi. He also gained the friendship of the anatomist and microscopist, Marcello Malpighi. Meanwhile, fostered by local contacts, his interest in Roman Catholicism developed, and in December 1667 he entered that Church. It seems clear that he took this step without any thought of gaining personal advancement; it led, ultimately, however, to his abandoning science for religion.

In the same month Steno received a summons to Copenhagen from King Frederick III of Denmark, with the promise of a professorship. He delayed his return for various reasons, and when he did set out, in 1668, he travelled north by a circuitous route, reaching Amsterdam in 1670. In the interval, Frederick III had died, and he also learnt that his patron, Ferdinand II, was ill, and so he returned to Florence again. Upon the death of the Grand Duke his patronage was continued by his son, Cosimo III.

Up to the time Steno first arrived in Italy, he seems to have devoted his life mainly to the study of anatomy and physiology, though not without other interests, as would be expected in a man with his brilliant intellect and inquiring mind. There is, however, no evidence that he had yet considered any of the geological problems which, even at this early date, before the science had gained a name, exercised the minds of not a few scientists. It may appear, at first glance, that there is no obvious link between anatomy and geology, and thus it may be wondered why Steno took up the study of the latter science. The answer is that, as with many of his anatomical studies, chance played a part, though it can scarcely be doubted that he had already discussed geological matters with his Italian friends. The problem of the origin of fossils, for example, had been considered by many Italian naturalists from the days of Leonardo da Vinci onwards. Moreover, in the same year that Steno arrived in Florence, Athanasius Kircher published a voluminous geological work, "Mundus Subterraneus", which most probably came to the notice of Steno. It appears that Steno first gave systematic consideration to the problems of geology through the circumstance that Ferdinand II placed at his disposal for dissection the carcass of a shark. His examination of the teeth led him to compare them with the fossil sharks' teeth known as 'glossopetræ', which were common objects in the Mediterranean region, and to be seen in private collections. Their true origin was still disputed, but Steno, as a skilled anatomist, could scarcely have failed to conclude that there was no essential difference between the fossil and recent varieties. This conclusion naturally raised in his mind a further question. Why are fossil organic remains found in rocks far from the sea? His first tentative views on these questions are contained in the book in which he describes his dissection of the shark[7]. To solve the problem, he did not indulge in speculation, as so many had before him, but went out into the countryside to study the rocks themselves. He published the results of his researches soon afterwards, in 1669, in a book bearing a title that gives little indication of its contents: "De Solido intra Solidum naturaliter contento Dissertationis Prodromus". The 'solids contained within solids' that Steno discusses were the fossils contained in rocks, and also certain minerals upon which, too, he made important original observations. Steno's "Prodromus" was intended only as a preliminary discussion of problems that he hoped to deal with at greater length later on, but, unfortunately, he did not do so. Even so, the importance of his book in the history of geology is outstanding. In it Steno lays down for the first time the fundamental principles of geology in a scientific manner, on the basis of field evidence. The principles stated, though somewhat crudely expressed, for the most part still hold good to-day, although not all the explanations advanced by Steno to explain observed facts were correct. Nor could this be expected at a time when geology was still a science very much in the embryo stage. It was not long before the importance of his book was realized outside Italy, and an English translation by Henry Oldenburg, secretary of the Royal Society, appeared in London in 1671. To the title of this edition Oldenburg added the significant words: "a Foundation for the Rendering a Rational Accompt both of the *Frame* and the several *Changes* of the Masse of the EARTH, as also of the various *Productions* in the same".

Physical science, too, aroused the interest of the versatile Steno, a fact to which attention has been directed by Dr. Axel Garboe[8]. The doctrine of *antiperistasis*, the current explanation of the relation between heat and cold, interested Steno, as it had other seventeenth-century scientists, including Robert Boyle. In Italy, for example, the presence of hot lava in snow-covered Etna attracted attention to the problem. Steno thought that two grottos in the remoter heights of the north Italian Alps, which were reputed to be permanently iced, might throw some light on the question; he therefore made the arduous journey to these grottos, carrying with him a Florentine thermometer, and was able to make observations showing that *antiperistasis* was not a valid explanation of the relation between heat and cold. His account of these journeys, contained in letters to Cosimo III, has been translated into English by Dr. Garboe[8].

Soon afterwards, in 1672, a second royal summons to return to Copenhagen reached Steno, and this time he obeyed it and returned to his homeland. On arrival he was created Anatomicus Regius, because, as a Roman Catholic, appointment to a university professorship was precluded. After his return, Steno made many anatomical demonstrations in the old Theatrum Anatomicum, accounts of which he published in a periodical newly established by his old master, Thomas Bartholin, the *Acta Medica et Philosophica Hafniensia*. However, though by now a somewhat more tolerant attitude towards the Catholics existed, yet his religious faith still made life difficult for Steno in Denmark, and there was, too, a serious conflict in his mind between the opposing calls of science and religion. In consequence, he returned once more to Florence, in 1674, where he became tutor to the son of Cosimo III.

Henceforwards, so far as is known, he abandoned the study of natural science, becoming increasingly interested in religious matters. He took holy orders in 1675, and was made a titular bishop in 1677, receiving the appointment of Vicar Apostolic of Northern Germany and Scandinavia. He then proceeded to Hanover and, after residing in various towns in northern Germany, he died in Schwerin in 1686. During these latter years Steno lived the life of an ascetic and devoted his energies solely to furthering the cause of the Church and the poor. After his death, his body was conveyed to Italy by Cosimo III and buried in the crypt of the church of St. Lorenzo, Florence.

Steno published many books and papers describing his anatomical and physiological researches into the glands and lymphatic system, the heart, the muscles, the brain and the reproductive system. These alone, apart from his contribution to geological science, would be sufficient to ensure for him an honoured name in the history of science. His scientific works have been published in a collected edition under the general editorship of Prof. Vilhelm Maar[1]. In this publication Maar has included a long introductory essay on the life and work of Steno, and an annotated bibliography. Both the essay and the annotations are in English and form the best source for English-speaking readers wishing to study the life and works of Steno. His theological works, too, have been issued in a collected edition[11], edited by Knud Larsen and Gustav Scherz, with an introduction and commentary in German.

Now this extensive collection of Steno's correspondence is available. A detailed review is not

practicable here; but a note on the contents of the volumes, particularly in so far as they bear on the history of science, will serve to show that this is a work of importance. It has been edited with great care and erudition, and all matter complementary to the letters is in German. A brief preface indicates that it contains all the letters both from and to Steno which the editors have been able to trace after searching a large number of European libraries and archives, especially those in Denmark, Italy and Germany. Doubtless others were searched with negative results but, while it is evident that the correspondence assembled must approach completeness, its publication may lead to further finds. At all events, it does not seem that possible British sources have been examined. Through the courtesy of the Librarian of the Royal Society, I am able to record that a contemporary copy of a letter from Steno to Dr. William Croone, dealing with medical matters, is still preserved in the Society's archives (though not the original of the other letter to Croone, published in the *Philosophical Transactions*). Its contents indicate a date not long before the publication of Steno's book on the dissection of the shark (1667). The correspondence covering the period of Steno's scientific activities is not extensive, and any additions would be welcome.

In the correspondence as printed, the term 'letter' is to be understood to include everything from friendly informal notes to formal documents such as episcopal communications with Rome. These are printed in the languages in which they were written, mainly Latin and Italian, and are arranged chronologically and numbered consecutively. They total 478, and range in time from a letter written by Steno in 1661 to Thomas Bartholin about his anatomical work to that written from his death-bed in Schwerin in 1686 to the Grand Duke Cosimo III. The editors state that about one-half of the letters printed are hitherto unknown, and only about one-eighth of the total have been published previously. Some are only printed in abstract, but references are provided to sources where they are given in full. Every letter is preceded by a summary of its contents in German, a great convenience for students with special interests. As indicated above, the number of letters of scientific interest is disappointingly few, in relation to the total, and those in Vol. 2, 253 in all, covering the period 1680–86, are mainly, if not exclusively, of theological interest. Fourteen letters that passed between Steno and Bartholin have been printed in full; and among other scientists to whom Steno addressed letters that have survived are Paolo Boccone, Athanasius Kircher, G. Leibniz, Marcello Malpighi, Francesco Redi, Swammerdam, Thévenot and Viviani.

Perhaps the most valuable part of the book for students of the history of science is the long introductory essay which discusses the seventeenth-century background, especially with reference to the life and work of Steno's correspondents. This is followed by an equally valuable index of sources consulted containing upwards of seven hundred references. Vol. 2 concludes with a number of "Additamenta". These include a reproduction of parts of what is known as the "Chaos" manuscript, a document preserved in the Biblioteca Nazionale in Florence, which contains a series of disconnected notes in Steno's handwriting dating from his student days. The additional matter also includes extracts from contemporary letters containing references to Steno and his work. Finally, there is an index of persons and places mentioned in the text.

The production of these two volumes must have required much research, apart from the laborious task of preparing the material for the press. The resulting work is a valuable contribution to our knowledge of the intellectual life of the seventeenth century, and it should find a place in all important reference libraries. As the editors point out, virtually all the material necessary for the preparation of a reasoned assessment of Steno's contributions to science and the Church, and for the preparation of a definitive biography, has now been assembled. It remains only for some author or authors, competent and willing to do so, to undertake the task. Such a biography would be of the greatest interest to students of the religious and scientific history of the seventeenth century.

V. A. Eyles

[1] "Nicolai Stenonis Opera Philosophica", 2 Vols., edited by Vilhelm Maar (Copenhagen, 1910). See also the shorter, but authoritative, accounts of Steno's life in English in V. Meisen's "Prominent Danish Scientists through the Ages", pp. 36–43 (Copenhagen and London, 1932); and J. G. Winter's edition of Steno's "De Solido . . . Prodromus" in Univ. Michigan Studies: Humanistic Series, 11, Contrib. Hist. Sci., Pt. 2, 175–187 (New York, 1916).

[2] "The Memoirs of Sir Robert Sibbald", edited by F. P. Hett, 57 (Oxford, 1932).

[3] Steno, N., "Discours . . . sur l'anatomie du cerveau" (Paris, 1669).

[4] See Skippon, P., "A Journey through part of the Low Countries, Germany, Italy and France . . . in company with the celebrated Mr. Ray, etc.", in "A Collection of Voyages and Travels", 6, 359–736 (1732). The reference is here quoted from Raven, C. E., "John Ray", first ed., pp. 132 and 137 (1942).

[5] Bodleian Library, Oxford. Lister MS. 5, Folios 224 (Verso) and 225: here quoted from Brown, H., "Scientific Organizations in Seventeenth-Century France", 211 (Baltimore, 1934).

[6] "An extract of a Letter not long since written from Rome, rectifying the Relation of Salamanders living in Fire", *Phil. Trans. Roy. Soc.*, No. 21, 377 (Jan. 21, 1666/7).

[7] "Elementorum myologiae specimen, . . . Cui accedunt canis carchariae dissectum caput . . ." (Florence, 1667).

[8] Garboe, A., "Niels Stensen (Steno) som Fysiker", *Fys. Tidsskrift*. 113 (Copenhagen, 1947).

[9] Garboe, A., "Niels Stensen's Grotto Letters", in "Hilsen Til J., Christian Bay", 15 (Copenhagen, 1951).

[10] "Nicolai Stenonis Opera Theologica", 2 Vols., edited by K. Larsen and G. Scherz (Copenhagen, 1941–47).

BOTANY IN THE UNIVERSITY OF GLASGOW

250TH ANNIVERSARY

At the opening in 1901 of the present Department of Botany in the University of Glasgow, the then director of the Royal Botanic Gardens, Kew, Sir William Thiselton-Dyer, said: "Had it not been for the work of Sir William Hooker in Glasgow University I do not think that Kew would be to-day what it is; and as the University looks to Bologna, so does Kew look to Glasgow". The long connexion between the Glasgow Department of Botany and the Royal Botanic Gardens at Kew was recalled and continued when the director of the Gardens, Sir Edward J. Salisbury, delivered a discourse on "The Creation of a Botanical Tradition" at the 250th anniversary celebrations of the Department on June 15, 1954.

The actual anniversary falls in September, for it was in that month of the year 1704 that John Marshall was appointed keeper of the Physic Garden and to give instruction in botany to students. He continued to teach until his death in 1719. A dual chair of anatomy and botany was founded in 1720 and for some time botany was regarded as the leading subject, perhaps out of deference to Thomas Brisbane,

the first holder of the chair, who refused to teach anatomy altogether and soon ceased to teach botany also. At this time occurs the first distinct notice of a University summer session for, in 1727, a Commission of Visitation ordained that Brisbane should teach botany from May 16 until July 1.

Brisbane died in 1742 and his successor, Robert Hamilton, is significantly described in the commission as "professor and *teacher* of Botany and Anatomy". It is doubtful, however, if Hamilton taught any botany, since William Cullen settled in Glasgow in 1744 and soon began to teach medicine, botany, materia medica and chemistry. He gave his botanical lectures in Latin and presented an account of the principles on which the different systems of botany had been founded. Cullen left for Edinburgh in 1756 and Hamilton died within three months. Joseph Black held the chair of anatomy and botany for a year and was succeeded by Thomas Hamilton, the brother of Robert. In 1781 Thomas resigned in favour of his son, William, who was to give botany a considerable share of his time until his death at the age of thirty-one in 1790. The King then appointed James Jeffray, who taught botany for some years; but after 1799 the subject was taught by Dr. Thomas Brown. Brown gave the first lectures on agriculture. After 1808 Jeffray seems to have again taught the botany class; but in 1816 the faculty agreed that Dr. Robert Graham should do it.

The College had had a Botanic Garden since 1704, although at various times it had been in danger of extinction. William Hamilton devoted much time and money to it; but, towards the end of the eighteenth century, cultivation, never easy on the stiff clay soil, became still more difficult owing to the impurity of the atmosphere. As the result of a public movement the Royal Botanic Institution of Glasgow was formed and a garden laid out at Sandyford. Graham, who was appointed first regius professor of botany in 1818, was much occupied with the laying out of the Garden until he left for Edinburgh in 1820 to superintend the formation of the new gardens in Inverleith Row.

In 1820 William Jackson Hooker was appointed with an unusual degree of swiftness to be regius professor, and he began that course of organization of public botanic gardens which continued to the day of his death. Scientific visitors to the Glasgow Garden almost invariably expressed the opinion that it would not suffer by comparison with any other similar establishment in Europe. Hooker had never lectured or even attended a course of lectures; but his tenure of the chair was remarkably successful. His lectures were attended not only by the medical students but by also the public and even by army officers. At the close of his first course the class presented him with a handsome silver vasculum chased with the design of a moss that had been named after him. He published a long series of works, illustrated by himself and by the Glasgow artist, W. Fitch, and made Glasgow a famous source of writing on descriptive botany which probably had no equal at its time. Hooker established a tradition of student excursions which has been carried on until the present day, and at the 1901 ceremony Sir Joseph Hooker described some of his father's excursions in the olden days when there were no railways, cycles, or motor-cars, and very few inns in the western Highlands. The accounts of these expeditions are often amusing, and occasionally professors and students became involved in court proceedings. In 1841 Hooker was appointed to be director of the Royal Botanic Gardens at Kew and was succeeded in Glasgow by John Hutton Balfour, who occupied the chair for only four years, passing on to Edinburgh in 1845, where he earned by his tough assiduity the title of "Woody Fibre".

The only professor of botany to have died in office was George Arnott Walker Arnott, who held the chair from 1845 until 1868. This fact had a marked effect on departmental history, for whereas his predecessors had, on leaving Glasgow, removed their collections and other effects elsewhere, Walker Arnott's library and herbarium were acquired after his death for the University. Throughout the nineteenth century the Glasgow chair of botany served as a stepping-stone to more valuable preferment elsewhere. Sir William Hooker passed on to Kew, Profs. Graham, Hutton Balfour, Dickson and Bayley Balfour (via Oxford) all moved to the chair at Edinburgh. At each step, collections, books and apparatus were removed. Those of Sir William Hooker formed the foundation of the scientific establishment at Kew, while the equipment of the others went to Edinburgh.

Arnott was followed by Alexander Dickson, who arrived just before the opening of the new University buildings in 1870. A beginning was now made in the establishment of a permanent Department of Botany, consisting of a large class-room at the top of the north-east corner tower, with a retiring room and a room for herbarium work, together with two badly lighted attics, without heat, water or gas. Dickson remained for eleven years and left the Department very much as it had been at Walker Arnott's death, except that the herbarium had become infested with beetles.

The vacancy in the chair in 1879 was filled by Isaac Bayley Balfour, a young man, full of energy, and fresh from the Continental schools. Balfour ensured the herbarium for the University. Having worked under Huxley and De Bary, practical classes seemed to him essential, and so he bartered his lecture-room for two small rooms that would serve as laboratories. These were too small for more than a fraction of the students; but they continued to be used for twenty years, first by Balfour and afterwards by Bower. Although Balfour is credited with having introduced practical classes in botany at Glasgow, it should be noted that Hooker required every student to provide himself with a pocket-lens, knife and pair of forceps, with which they followed the professor's demonstrations.

By 1840 the Sandyford site had become unsuitable for the Botanic Garden owing to the spread of the City and so the plant houses were removed to the rural area of Kelvinside in 1842. The Garden was still controlled by the Royal Botanic Institution, and the professor of botany did his teaching in the Garden until 1870. The plant houses became very dilapidated and the herbaceous ground very cramped; but with the support of Sir Joseph Hooker (by that time director of Kew), Bayley Balfour rehabilitated the Garden. His costly schemes hastened the transfer of the Garden to the Corporation, which finally took place in 1891, although the University still retained facilities for the teaching of botany in the Garden.

For forty years from 1885 Frederick Orpen Bower was regius professor, and his greatest domestic botanical achievement was undoubtedly the building of the present Department of Botany. Botany was thus the first science to have a separate building in Glasgow, and although the Department is now short

of space, it seemed, in 1900, that Bower had been absurdly extravagant in his provisions. The building was opened in 1901 by Sir Joseph D. Hooker in the presence of Sir William Thiselton-Dyer, Lord Lister and Prof. Bayley Balfour. The jubilee of this event was celebrated in 1951 when the late Prof. F. E. Fritsch was the Department's guest of honour.

During Bower's professorship Robert Kidston was closely associated with the Department, and members of the staff who afterwards became well known elsewhere include J. M. F. Drummond, D. T. Gwynne-Vaughan, W. H. Lang, A. Anstruther Lawson, J. McLean Thompson and J. C. Willis.

The Department continued to grow steadily during the remainder of Bower's time and also during that of his successors, Prof. J. M. F. Drummond and Prof. John Walton (the present incumbent). The need of new laboratories for plant physiology and mycology became felt increasingly and Prof. Walton's striving to obtain these recalls the vigorous efforts of Bower at the end of last century to get a botany building. The result was the Stevenson Laboratory, which was opened by Sir Albert Seward in 1937.

The latest event in the Department's history was the celebration on June 15 of its 250th anniversary. Representatives of many university departments of botany and of the Botanical Society of the British Isles and the Botanical Society of Edinburgh were present and the guest of honour was Sir Edward Salisbury, thus maintaining the link with Kew. In his discourse, Sir Edward referred to the achievements of the Glasgow Department and showed how, through times of prosperity and adversity alike, the advancement of botanical knowledge has there been fostered and ensured. Remarking that a wise man exploits the characteristic features of his environment, Sir Edward said that the Cryptogams had continually been studied in "the perpetually humid atmosphere of Glasgow" where ferns, liverworts and mosses flourish. For Hooker, pteridology "was a major activity in a varied career, and for Bower the absorbing obsession of a lifetime". He added: "Just as the University is far more than a mere assemblage of the faculties of which it is comprised, so, too, the history of a department far transcends the mere succession of professors and teachers, however eminent. It is the good fortune of botany at Glasgow that it has had so high a proportion of those, doing it service, who have not only been gifted in their own field of study, but have been scholars with that intellectual apprehension of proportion and perspective, that is beauty".

Before the discourse (at which the vice-chancellor, Sir Hector Hetherington, presided) the guests and visitors were photographed and entertained to luncheon and tea. Afterwards an anniversary dinner was held, at which speeches were made by Prof. S. C. Harland, Prof. J. D. Mackie (representing the Vice-Chancellor), Prof. J. McLean Thompson, Dr. S. Williams, Dr. G. Bond, Sir Edward Salisbury and Prof. A. R. Gemmell. An exhibition of portraits, letters and various other documents relating to the history of the Department was on show during the day.

It was a matter of great regret to all present that illness prevented Prof. John Walton from presiding over the celebrations. A message from him was read by the Vice-Chancellor and good wishes were sent from the assembly. Prof. Walton's place was taken by Dr. Samuel Williams, the acting head of the Department.

FUNDAMENTALS OF COLOUR REPRODUCTION*

By Dr. R. W. G. HUNT

Kodak, Ltd., Wealdstone, Harrow, Middlesex

WHEN, during the first half of the nineteenth century, certain indefatigable people strove to 'fix the images of Nature', their purpose and hopes were to fix the colours as well as the tones in their pictures, and it would no doubt have seemed to them like an idle tale if some prophet had revealed that photography was to know a hundred years of black-and-white before colour began to intrude in any measure. Yet such is the case, and this in spite of a number of early milestones which held out great promise. As early as 1810, Seebeck and others knew that if a spectrum was allowed to fall on moist silver-chloride paper many of its colours were recorded, although not with any degree of permanence. In 1853 Prof. Robert Hunt published the third edition of his "Photography", which contained a whole chapter "on the possibility of producing photographs in their natural colours"; he described seeing a number of "Heliochromes" which were "perfectly coloured; . . . but the colours soon faded, and it does not appear as yet that any successful mode of fixing the colours has been discovered". By 1890, however, Prof. Gabrielle Lippmann, of Paris, had not only perfected the technique of 'fixing' these colours (by the same methods as are used in black-and-white photography) but had also much improved the process in other ways. Moreover when, just before and just after the turn of the century, sensitizing dyes such as eosin, cyanine blue, ethyl red and (above all) pinacyanol were discovered, greatly increasing the sensitivities of photographic emulsions in the green, yellow and red parts of the spectrum, Lippmann colour photographs of very high quality, even by present-day standards, were produced.

The method, which is illustrated in Fig. 1, is an interference process. During the exposure, the emulsion is backed by mercury, so that the light is reflected back through the emulsion layer, and interference occurs between the incident and reflected beams. Standing waves are formed in the emulsion layer, and hence the latent image is formed in bands at half-wave-length intervals. The emulsion is composed of extremely fine grains so that these bands are resolved, and after development and fixing (in 'hypo' in the usual way) there remain a series of bands of silver separated by distances equal to half the wave-length of the exposing light. Since the grain-sizes are small compared with the wave-length of light, the bands of silver act as mirrors and selectively reflect light of the same wave-length as that which produced the image. It is probably true to say that, but for one fact, colour photography would have started a brilliant career at the turn of the present century by means of the Lippmann method. The one fact is that, in photographic emulsions, the finer the grain, the lower the sensitivity. Lippmann emulsions must have grain-sizes which are small compared with the wave-length of light, and the corresponding sensitivity is such that exposures of the order of half an hour in bright sunlight are

* Based on a course of four lectures delivered at the Royal Institution, London, on November 5, 12, 26 and December 3, 1953.

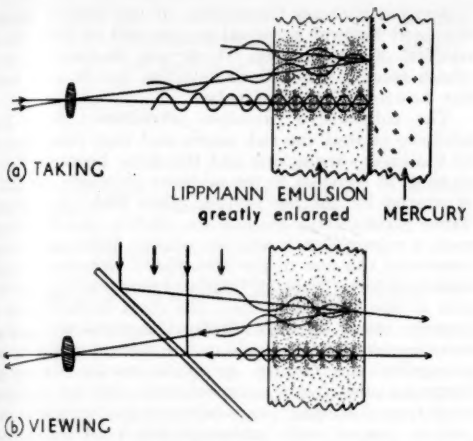

Fig. 1. The Lippmann method of colour photography. (*a*) Taking : in this example the horizontal beam represents green light, and the oblique beam, red light. (*b*) Viewing : the Lippmann photograph is viewed by reflexion ; from the incident white light, the bands of silver selectively reflect green light in the horizontal beam and red light in the oblique beam

necessary to produce good Lippmann colour photographs.

So the early dreams of Seebeck, Hunt and others were dashed, not by the difficulty of fixation, but by low sensitivity. The Lippmann process, however, is important to any consideration of the fundamentals of colour reproduction because, apart from the micro-dispersion method (which is often described but never used), it is the only successful method in which the colours are reproduced physically. For any colour is completely defined by its spectral-energy distribution curve, and in a Lippmann colour photograph the attempt is made to reproduce, at each point on the photograph, a colour having the same spectral-energy distribution curve as in the original.

The recording and presentation of so much information in a colour reproduction, however, has long since been known to be unnecessary. For two spectral-energy distribution curves can be very dissimilar, and yet constitute colours which are visually identical ; and so we find that the early pioneers were on the wrong track, and that all successful modern methods of colour reproduction, whether in photography, in printing, or in television, stem from a different source.

In 1801, Thomas Young, from physiological considerations, decided that the eye must simplify the complexity of the infinite number of variables in the spectral-energy distribution curve, and proposed that only three variables were involved. This suggestion, which was later to be much elaborated by Helmholtz, came to be known as the Young–Helmholtz, or trichromatic, theory of colour vision.

Young's original pronouncement preceded the invention of photography by about thirty years, and another thirty years were to pass before Maxwell, in his famous Friday Evening Discourse at the Royal Institution on May 17, 1861, demonstrated Young's hypothesis by trichromatic colour photography. Maxwell's thesis was that, if the eye really does analyse all colours into only three variables, 'redness', 'greenness' and 'blueness', then by preparing three negatives, one through a red filter, one through a green filter, and one through a blue filter, and making from them three positive lantern slides, then projecting them in three lanterns fitted with red, green and blue filters, respectively, and superimposing the three images thus obtained, all the colours of the original scene would be reproduced. Maxwell's work, of course, was done thirty years before sensitizing dyes became available, so that the red and green filters used in making the exposures had to be rather pale in order that any image be obtained, even when lengthy exposure-times were given. In consequence, the quality of Maxwell's colour photograph was poor, and, indeed, his purpose in showing it was only to demonstrate the truth of Young's theory of colour vision, and not to lay the foundation stone of successful colour photography. In point of fact, however, this is precisely what he did. His experiment, moreover, is not only basic to colour photography, but to colour reproduction in other media, such as printing and television. Moreover, once satisfactory sensitizing dyes had been produced, Maxwell's method became capable of a standard of excellence in colour rendering which even to-day has not been surpassed, and is seldom equalled. But the inconvenience of three separate projectors, with all the difficulties of obtaining and maintaining exact registration of the three images, has consigned the triple-projection method to the museum and the lecture bench, although in recent years it has been tried again in colour television.

The half-century following Maxwell's discourse produced a veritable spate of arm-chair inventions, and some of the leading inventors of the time showed extraordinary thoroughness ; it has been said, for example, of Louis Ducos du Hauron that "there is scarcely a process which he did not foreshadow", and as early as 1869 he realized the distinction between the additive and subtractive principles (both of which derive from Maxwell's experiment in the final analysis).

In photography, the additive processes have had a long and chequered career, but are now almost entirely superseded by subtractive processes. It is very interesting to note, however, that, in colour television, methods are being used which are very similar indeed to the early methods of additive colour photography, and in this respect television is unwittingly recapitulating the history of photography with remarkable precision.

Thus triple projection has been used in colour television and, as in photography, is perhaps also in television the method capable of the highest quality, but with the same attendant difficulties of exact registration and cumbersome equipment.

One of the most attractive ways of simplifying the equipment was to view the three positive images, not simultaneously, but successively, and fifty years ago colour cinematography by means of rotating filter wheels having red, green and blue sectors raised the hopes and emptied the pockets of many an optimist. In television, this method was tried in the early 1930's by Baird, and in the form of the Columbia system was approved by the Federal Communications Commission in the United States in 1950. Unfortunately, in such a system, the blue filter is always much darker than the red and green filters, and the eye can detect the darker filter as a brightness flicker, even when the speed of the filter wheel is fast enough to remove all colour flicker. In fact, in order to remove all trace of flicker it is necessary to present the successive pictures at the

rate of about 144 per second, and this requires excessive band-width in transmission. Even at this speed, however, moving objects can sometimes exhibit fringes (colour 'break-up') which are irritating to the viewer. Moreover, this high picture-frequency renders the system 'incompatible'; that is, colour pictures cannot be viewed as black-and-white pictures on existing (black-and-white) receivers, and it was perhaps as well that defence requirements prevented the widespread use of the Columbia system and made it possible for the Federal Communications Commission to approve a compatible system in 1953.

One of the most ingenious of the additive methods of colour photography was the lenticular method. The camera lens was fitted with three strips of red, green and blue filter, and the film was loaded with the emulsion facing away from the lens. The film base had furrows, or lenticulations, embossed upon it, which acted as tiny cylindrical lenses and imaged the red, green and blue strips on to the emulsion, thus analysing the picture into very fine strips exposed through red, green and blue filters. Projection was carried out in a closely analogous manner, using lenticulated films and strips of filter over the projection lens.

The counterpart to the lenticular system in colour television is the Lawrence tube. This has a large number of vertical wires fixed just behind the screen of the cathode-ray tube, and potentials are applied in such a way that a series of lenticular electron lenses is formed. Red, green and blue phosphors are deposited on the surface of the tube in vertical strips, and the potential on the wires is arranged, at one moment, so that the electrons strike only the red phosphor, say. At the next moment, by altering the potential on the wires, the electron lens is altered so that the electrons fall on the green phosphor, say. A further alteration of potential on the wires causes only the blue phosphor to be excited at the next moment. By switching the potentials at any suitable frequency above that necessary to eliminate flicker and colour break-up, a satisfactory colour picture is obtained.

In colour photography, however, the most successful additive processes were those which used mosaics of tiny red, green and blue areas, behind which the negatives were made, and through which the positives were viewed. In this system each original patch of colour is broken up into areas of red, green and blue, too small to be seen separately by the eye. The mosaic pattern was sometimes random, and sometimes regular, the latter being preferable because, in the former, random clumps of areas all of the same colour give rise to a mottled appearance. Again, it is most interesting to see that the additive method which in the end proved the most successful in colour photography is, at any rate so far, the one which has proved most successful in colour television. The type of tube originally developed by the Radio Corporation of America, which is beginning to be used in the United States, contains on its surface a regular array of triads of dots of red, green and blue phosphor. An aperture plate just behind the surface, with one aperture for each triad of dots, acts as a rough pin-hole camera, and 'images' three electron guns on to the three dots. The arrangement provides, of course, for one gun to be imaged on to all the red dots, another on to all the green dots, and a third on to all the blue dots. Mainly as a result of work carried out by the Radio Corporation of America in this field, the National Television Systems Committee of the United States obtained Federal approval at the end of 1953 for a method of transmission which was compatible, and which could be used both with the R.C.A. and with the Lawrence types of tubes.

The subtractive principle is different from the additive in that the red, green and blue components of the image are in one and the same beam of light, so that, in contrast to the additive principle, no light is wasted by the use of red, green and blue filters. Three positive dye images are made; one dye is of such a colour that it absorbs reddish light and freely transmits the rest of the spectrum; another is such that it absorbs greenish light and freely transmits the rest of the spectrum; and the third is such that it absorbs bluish light and freely transmits the rest of the spectrum. The colours of dyes having these properties are known in photography as cyan, magenta and yellow, respectively, but in printing they have for many years been termed blue, red and yellow, respectively (although the blue is slightly greenish, and the red is slightly bluish). The three dye images, when superimposed and viewed in white light, give a satisfactory trichromatic colour reproduction, because the reddish part of the white light is controlled by the cyan dye, the greenish part by the magenta dye, and the bluish part by the yellow dye. It is difficult to see at present how the subtractive principle could be profitably applied to colour television, but in colour photography it has met with very considerable success during the past two decades, particularly in the form of 'integral tripacks'; that is, systems where three emulsion layers are coated in succession, one on top of the other, on the same film base.

In printing, the number of inks used is not always confined to three. Frequently a black printing is added, and special colours—for example, a particular shade of blue—are sometimes printed in separately as well. Sometimes as many as seven or eight different inks are used, and, in this case, colorimetrically the reproduction is more analogous to painting than to photography or television.

Most methods of printing result in the inks being deposited in regular mosaics of dots, and since the mosaics of the different inks overlap in some places, but not in others, the system is partly additive and partly subtractive. Neugebauer[1] has treated the problem quite generally as an additive mixture of eight different colours: cyan, magenta, yellow, red (magenta and yellow superimposed), green (cyan and yellow superimposed), blue (cyan and magenta superimposed), black (all three dyes superimposed), and white (the colour of the paper). Hardy and Wurzburg[2] have proposed an ingenious system of scanning the original colour scene and printing arrays of dots photographically on three separate plates, such that, when these arrays of dots are printed in cyan, magenta and yellow dyes, exact colour reproduction is achieved. Clapper and Yule[3], however, have pointed out that inter-reflexions of light within the layers of ink and the paper fibres introduce errors; but the system is still capable of producing very good results and, in fact, is being increasingly used.

We have seen that a great deal of effort has been expended by many workers over a period of more than a century in the hopes of reproducing colour. Yet even to-day the vast majority of photographs, television pictures and printed reproductions are only in monochrome. The problems to-day, however, are mainly economic and not technical. Colour snap-

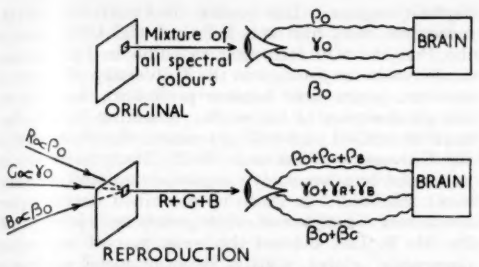

Fig. 2. Diagrammatic representation of why a trichromatic reproduction of an original scene is always inaccurate

shots, cinematograph films, lantern slides, prints, television pictures and printed reproductions have all been, and are all being, produced. Perhaps in fifty or a hundred years time the black-and-white reproduction will be a thing of the past, but only if economic and political factors allow.

There remains one question yet to be answered. How accurate can these colour reproductions be? Since Lippmann and other physical methods of colour reproduction are generally impracticable, the question is really of interest only in the case of the trichromatic methods. The situation in these methods is shown schematically in Fig. 2. The upper half of the diagram represents the situation in which the original object is viewed. Physically, the colour consists of a mixture, in certain proportions, of all the colours of the spectrum. This physical complexity is then, according to the Young–Helmholtz theory, simplified physiologically into three variables only; the magnitudes of these three variables are denoted by ρ_0, γ_0 and β_0 and, according to the theory, the sensation of colour produced by the object is a function of these variables only.

These three signals ρ_0, γ_0 and β_0 may be thought of as being produced by three types of light-sensitive cells in the retina, each having a different spectral-sensitivity curve. Since trichromatic colour reproduction depends for its success on the properties of the eye, it is clear that any system must analyse the colour of the object in the same way as the eye. Hence the three separation images must be recorded by light-sensitive receivers having the same spectral-sensitivity curves (or in certain circumstances any three linear combinations of them) as the three different types of light-sensitive cells in the retina. Although much remains unknown about the mechanism of colour vision, if the Young–Helmholtz theory is accepted these spectral sensitivity curves can be deduced from colour-matching experiments to a considerable degree of accuracy. It is thus possible to select filters for use with photographic emulsions or television camera tubes which result in sensitivity curves closely approximating those required. Three signals are thus obtained proportional to ρ_0, γ_0 and β_0, and, in television, these signals (or combinations of them) are transmitted to the receiving sets, while in photography positives are made from the negatives. Beams of red, green and blue light are then combined to form the colour picture, either additively as in colour television and additive photography, or by the independent modulation of the reddish, greenish and bluish parts of the spectrum as in subtractive photography and in printing. The intensities, R, G and B, of these beams of light are made as nearly as possible proportional to ρ_0, γ_0 and β_0, and if the red light stimulated only the ρ-type of cell, the green light only the γ-type, and the blue light only the β-type, the signals received by the brain on looking at the colour reproduction would be proportional to ρ_0, γ_0 and β_0. It would then only be necessary to adjust the overall intensity of the picture to obtain signals equal to ρ_0, γ_0 and β_0, and hence exact colour reproduction.

The essential conditions for exact colour reproduction may, therefore, be summarized thus: (*a*) analysis of the scene by sensitive elements with the correct spectral-sensitivity curves; (*b*) production of red, green and blue beams of light with intensities proportional to the analysis; (*c*) stimulation by the red, green and blue beams of light of the three types of retinal cell separately; and (*d*) correct adjustment of the overall intensity of the picture. Conditions (*a*), (*b*) and (*d*) can, at least in principle, be well enough approximated to. But condition (*c*) is impossible to realize. Even if the red, green and blue stimuli are carefully chosen monochromatic radiations, the green stimulus invariably excites not only the γ-type of cell but also the ρ- and β-types. Moreover, the use of monochromatic stimuli is precluded in practice by the difficulty of obtaining sufficient intensity, and broader bands of light have to be used. This results in the red and blue stimuli also causing unwanted excitations, and the situation arises wherein the red light gives rise to the wanted signal ρ_0 and an unwanted γ-signal γ_R. The green light results in the wanted γ_0 and in unwanted signals ρ_G and β_G; and the blue light results in the wanted β_0 and in unwanted signals ρ_B and γ_B. The situation that arises is then shown schematically in the lower half of Fig. 2. Instead of the brain receiving the signals ρ_0, γ_0 and β_0, as required, it receives signals $\rho_0 + \rho_G + \rho_B$, $\gamma_0 + \gamma_R + \gamma_B$ and $\beta_0 + \beta_G$. Now the vividness, or saturation, of colours depends on the ratios of the three signals to one another, and additions to all three signals inevitably decrease the ratios. Hence the inability to satisfy condition (*c*) results in practically all colours, but particularly greens, being reproduced too pale.

This effect is in no way dependent on the Young–Helmholtz theory and would be just as true, though more difficult to describe, even if the theory were false.

In subtractive colour photography this effect is enhanced by the fact that the red, green and blue lights have, of necessity, to be broad bands of the spectrum; and the cyan, magenta and yellow dyes also have unwanted absorptions which cause green and blue colours to be reproduced darker than in the original scene. In colour television, however, by solving linear equations electronically, the effects of the violation of condition (*c*) can be limited to those few colours which are too vivid to be matched by any mixture of the red, green and blue lights; in practice, however, this refinement is not usually worth while.

How accurate can colour reproduction be? We have shown that trichromatic colour reproduction can never be perfectly accurate, because of the inevitable violation of condition (*c*). But, in practice, trichromatic colour reproductions are often very satisfactory, and, in fact, the public sometimes feel that the colours are not too pale, but too vivid. It is probable that this feeling arises from violation of condition (*b*); by making the picture of much higher contrast than the original, some increase in the saturation of the colours can be obtained, and this device is often used to lessen the effects of violating

condition (c). The final saturations of the colours, however, are very seldom greater than those of the original, and are usually considerably less.

Why, then, can trichromatic reproductions be so acceptable? The answer lies very largely in the fact that they are scarcely ever seen alongside the original scenes, and the quality of the reproduction is judged against a mental conception of what the scene probably looked like. But scenes vary tremendously in their colour qualities, and particularly so in colour saturation, according, for example, to the type of lighting and the atmospheric conditions. Moreover, colour reproductions are generally viewed under conditions very different from those of the original scene, and this introduces a number of complicating subjective effects, which depend on the size, brightness and surface both of the picture and its surroundings.

Of colour reproduction, it must be said that accurate methods are impracticable, and practicable methods are inaccurate; and some may be inclined to add that all methods are too expensive. But the urge to 'fix the images of Nature' is just as insistent as it was a century ago, and there are some signs that the early trickles of hope are at last becoming the full floods of success.

[1] Neugebauer, H. E. J., *Z. tech. Phys.*, **36**, 22 (1937).
[2] Hardy, A. C., and Wurzburg, F. L., *J. Opt. Soc. Amer.*, **38**, 300 (1948).
[3] Clapper, F. R., and Yule, J. A. C., *J. Opt. Soc. Amer.*, **43**, 600 (1953).

OBITUARIES

Prof. K. N. Bahl

Karm Narayan Bahl, who died at Lucknow on April 21 in his sixty-fourth year, was one of the great leaders in Indian zoology, and his work is known and admired throughout the world.

He was born on February 14, 1891, at Multan, in the Punjab, and educated at the Government College, Lahore, where he graduated B.Sc. in 1911 and M.Sc. (first class) in 1913, when he was also awarded the Maclagan Gold Medal. As soon as he had taken his B.Sc. he began his university teaching career by becoming demonstrator and assistant professor at Lahore; in 1914 he was appointed professor at the St. John's College, Agra, and in 1916 at the Muir Central College, Allahabad. His first research was on the ant-like spiders of the family Attidæ; but then he turned to the study of the Indian earthworms and very soon made the outstanding discovery of a new type of nephridium. In 1919 he published the first of a series of important papers on earthworm anatomy which appeared during the next thirty years in the *Quarterly Journal of Microscopical Science*; in this first one he described three distinct kinds of nephridia—septal, pharyngeal and integumentary—which he found in the worm *Pheretima posthuma*. It was the septal nephridia which presented such an interesting novelty, for they opened not to the outside of the body, as in all other such organs, but into the intestine; he called them an enteronephric system and made the suggestion, which in later years he strongly supported by experiment, that they were an adaptation for the conservation of moisture in a dry climate. He then visited England to work for two years under Prof. Goodrich at Oxford, where he was awarded the D.Phil. for further studies on *Pheretima*, in which he worked out the blood-vascular system and the development of the enteronephric organs. His earlier discovery had in the meantime won him the D.Sc. of the University of the Punjab. On returning to India in 1921 he was made reader in zoology in the University of Lucknow and two years later became professor; here he did the greater part of his work, remaining in the chair until he retired and was appointed vice-chancellor of the University of Patna in 1951. Many more studies in earthworm anatomy, reproduction and development followed; in these he described enteronephric systems in a number of other genera and, jointly with Dr. M. B. Lal, showed the existence of a 'hepatopancreatic' gland, with a hepatic portal system, in worms of the genus *Eutyphoeus*. His morphological work was not, however, confined to earthworms; he produced, in the *Records of the Indian Museum*, an outstanding monograph on the skull of *Varanus monitor* with its associated muscles, blood-vessels and nerves. He was awarded the D.Sc. of Oxford in 1938, and in 1942 received the Joy Gobind Law Memorial Gold Medal of the Asiatic Society of Bengal.

Bahl's leadership will continue to be felt in India and the East for many years to come through that excellent series of *Indian Zoological Memoirs* which he initiated and edited. Since he wrote the first on *Pheretima*, seven others, by different authors, have dealt in turn with selected types of the Indian fauna; they are the oriental counterparts of the well-known *Liverpool M.B.C. Memoirs* which have played so important a part in the training of English zoologists. In the words of a review which appeared in *Nature* some years ago, "zoologists in India owe a debt of gratitude to Prof. Bahl to whose enthusiasm this series of manuals is due". The debt will grow and extend through many countries as these memoirs become more widely used; there could be no better memorial to Bahl than this series of volumes. On his retirement he was made a research professor at Lucknow, but his sense of duty then compelled him to accept a pressing invitation to become vice-chancellor of Patna University; here his heavy duties proved too much for him and in 1952 he suffered a breakdown in health from which he never completely recovered. Our sympathy goes to his wife, three sons and a daughter who survive him.

A. C. Hardy

Dr. R. S. Clay

Reginald Stanley Clay died on April 10, after a short illness; he was eighty-five.

Dr. Clay's interests were many and various. He was educated at Tollington Park College and St. John's College, Cambridge, becoming a Wrangler in 1892. His first professional appointment was as physics master at Mill Hill School, and in 1897 he became head of the Physics Department at Birkbeck College. In 1900 he was appointed principal of the Wandsworth Technical College and in 1902 was invited to become the principal of the Northern Polytechnic. There he found ample scope for the exercise of his professional qualifications and administrative ability, which, with his power of winning the sympathetic co-operation of his staff and the respect of his students, enabled him, during his twenty-nine years of office, to make the Institute more widely known and to bring it to a high degree of efficiency. In 1931 he retired, to the regret of all who had been associated with him either as colleagues or students.

During 1907–11 Dr. Clay was the secretary for the Association of Technical Institutions, and in 1936 he joined the board of directors of the United Kingdom Optical Co. at Mill Hill, with happy results for the firm. From 1942 he served the Company as technical consultant on many problems. He was a founder fellow of the Institute of Physics (1918), served on its Board during 1920–33, and in recent years helped to promote the education and training of laboratory technicians. For many years he did admirable work for the *Journal of Scientific Instruments*, was at one time chairman of the Advisory Committee and was himself a frequent contributor.

Throughout his life, Dr. Clay's chief interest and hobby lay in optics. He was a member of the Council of the Optical Society and its president in 1927. Having been a Fellow of the Royal Microscopical Society for some years, he became its president in 1937 and was made an honorary Fellow shortly before his death. He was also a member of the Physical Society, in the activities of which he took a keen interest.

In 1911 Dr. Clay published a "Treatise on Practical Light" which remained the standard text-book for many years. It describes many ingenious pieces of apparatus for demonstrating optical principles. He gathered a unique collection of microscopes, containing an almost complete series from 1670 to 1850. This collection, bearing his name, is now in the Museum of the History of Science, in Oxford, and is described in detail in a book published in collaboration with T. H. Court in 1932, on the "History of the Microscope"; this remains the standard work on the subject.

From 1904 to the end of his life he was closely associated with what is now the National Council for Domestic Studies, being its first treasurer and chairman of the Examination Board. During thirty-seven years he was only absent from the chair on three occasions, and he personally signed nearly thirty thousand certificates. He was particularly interested in training girls in a scientific approach to home life. One of Dr. Clay's major interests was the North London Collegiate School for Girls, now at Canons Park, where he became a governor, representing the Worshipful Company of Clothworkers, in 1929, and chairman of the governors from 1938 until his death.

During both World Wars, Dr. Clay played a part in supplying the Services with optical instruments, and during the second he was attached to the Admiralty Establishment at Teddington, acting as liaison officer between it and various aircraft depots.

On retiring from the Northern Polytechnic, he took an active interest in the Islington Antiquarian and Historical Society, becoming its president in 1948. His interests also extended to the Organ Club, the Newcomen Society, the British Society for the History of Science and the Cactus and Succulent Society. For many years he was an honorary member of the British Acetylene Association.

Dr. Clay married Theodora Tilley, and in 1947 they celebrated their golden wedding.

Dr. Clay's great gifts were consecrated to great ends. He sought to help others and to make life easier and happier for them. He had the power of inspiring respect and affection in others by his cheerful and friendly personality. To all who genuinely sought his guidance he gave freely of his time and knowledge, and he leavened his many activities with a graciousness that endeared him to all.

W. L. Doughty

NEWS and VIEWS

G. S. Ohm (1787–1854)

The German physicist, Georg Simon Ohm, whose name is immortalized in the ohm, Ohm's law and the ohmmeter, died a century ago, on July 7, 1854. Son of a master locksmith, he was born at Erlangen in Bavaria on March 16, 1787, and entered the local University at the age of sixteen, but left after eighteen months because of lack of means. After holding teaching posts in Switzerland, he returned to Erlangen in 1811, graduated and taught as *Privatdozent*. In 1817 he was appointed professor of mathematics at the Jesuit's *Gymnasium* in Cologne, where by means of experiments made with great skill and care, though with poor and deficient apparatus, he established his law of the theory of the voltaic current, which he published at Berlin in 1827 under the title "Die galvanische Kette mathematisch bearbeitet". Ohm's law, which to-day is regarded as a commonplace, was far in advance of its time, and its announcement fell on deaf ears. Deeply hurt, Ohm resigned his post and led a precarious existence until after many petitions addressed to the King of Bavaria he was made professor of mathematics at the Nuremberg Polytechnic in 1833. The Royal Society of London was the first to appreciate his work, awarding him its Copley Medal in 1841 and in the following year electing him a foreign member. In 1843 Ohm announced his law on the production of complex tones by the composition of simple vibrations. In 1852 he became professor of physics at the High School in Munich, where he died of apoplexy two years later. Small in stature, feeble in body, ample in taste, he never married and lived solely for his work.

Geography at University College, Leicester: Prof. Patrick W. Bryan

Prof. Patrick W. Bryan retires from the chair of geography and the vice-principalship of University College, Leicester, at the end of the present session, and has been appointed the first professor emeritus of the College. He received his early training in geography and economics at the London School of Economics under the late Sir Halford Mackinder; early in his career he spent a year at the University of Chicago, where he came under the influence of the school of geography then developing—the 'human ecology' school. The advanced text-book on North America, which was the joint work of the late Prof. Rodwell Jones and Prof. Bryan, was the first in the now well-known Methuen series, and his studies on the corn belt in particular illustrate Bryan's meticulous attention to relevant detail. He will always be associated with the development of the concept of the 'cultural landscape', elaborated in his book "Man's Adaptation of Nature". He was criticized by some for seeking an easy correlation between the features of the landscape and present

human occupance; but his ideas have been absorbed in modified form in much current work. Known in later years as a great exponent of visual presentation of geographical facts, his wide circle of friends will wish him a long and profitable retirement, with leisure to follow his photographic interests.

Mr. Norman Pye

Mr. Norman Pye, senior lecturer in the University of Manchester, is to succeed Prof. Bryan. Mr. Pye was educated at Wigan Grammar School and at the University of Manchester, where he graduated with first-class honours in geography in 1935 and obtained the diploma in education in 1936. After a period as a research student at St. Catherine's College, Cambridge, he returned to Manchester in 1938, as an assistant lecturer in geography; he served in the Hydrographic Department of the Admiralty during 1940–46. He was appointed to a lectureship at Manchester in 1946 and became senior lecturer in geography in 1953. During 1944–46 he held jointly with Dr. W. G. V. Balchin a Leverhulme Research Fellowship for climatological research in Bath and district. During 1952 he received a Fulbright travel grant for research, also with Dr. W. G. V. Balchin, in geomorphology and economic geography in the Mohave and Sonora Deserts, U.S.A. Since 1950 he has been honorary assistant editor of *Geography*. He is also a member of the Council of the Institute of British Geographers and of the Council of the Royal Meteorological Society. Mr. Pye's special research interests have been in the field of physical geography, more especially in climatology and cartography, on both of which topics he has published a number of papers and has now in the press a book on the principles of cartography and surveying. He is also much interested in, and has had considerable experience of, teaching and lecturing on both economic and regional geography. He is also a first-class man in the field and has conducted field courses both in Britain and in European countries.

Royal Society and Nuffield Foundation Commonwealth Bursaries Scheme: Awards

Awards under the Royal Society and Nuffield Foundation Commonwealth Bursaries Scheme have been made to the following: Prof. R. H. Common, chairman of the Department of Agricultural Chemistry, McGill University, to enable him to study avian biochemistry, principally at Reading, during July–September; Dr. D. E. Coombe, Fellow of Christ's College and University demonstrator in botany, Cambridge, to enable him to visit West Africa during 1955 to study tropical forest vegetation; Dr. J. Crossland, lecturer in physiology, University of St. Andrews, to enable him to visit Montreal during August–December 1954 in order to collaborate with Dr. K. A. C. Elliott in further studies in the behaviour of acetylcholine in the brain; Mr. J. R. Howes, lecturer in animal husbandry, Imperial College of Tropical Agriculture, Trinidad, to enable him to study problems and methods of research in African animal production, at Pretoria and in Kenya, during July–September; Dr. A. P. Subramaniam, of the Geological Survey of India, to enable him to work with Prof. C. E. Tilley at Cambridge during 1955 on a petrographic study of rocks from the type charnockite area around Madras; Mrs. Patricia M. Thomas, of Adelaide, to enable her to carry out helminthological studies at Macdonald College, Canada, during July–December. These are the first awards under the scheme which was instituted last year to provide facilities for increasing the efficiency of scientific workers of proved ability by enabling them to pursue research, learn techniques or follow other forms of study in natural science in countries other than their own in the British Commonwealth where the physical or personal environment, or both, are peculiarly favourable.

Royal Society Research Appointments

The Council of the Royal Society has made the following research appointments: the Alan Johnston Lawrence and Moseley Research Fellowship to Dr. D. S. Robinson (Sir William Dunn School of Pathology, University of Oxford) for work on the biochemistry of lipid distribution and transport in plasma, and its relation to the problem of atherosclerosis; Stothert Research Fellowships to Dr. B. L. Ginsborg (University College, London) for work on neuromuscular transmission, and to Miss D. Salmony (Courtauld Institute of Biochemistry, Middlesex Hospital Medical School, London) for work on the effects of sex hormones on cell metabolism; and the John Murray Travelling Studentship in Oceanography and Limnology for 1954 to P. Hughes (University of Liverpool) for study of wind drifts in the oceans.

Atomic Energy Authority

The Atomic Energy Act, 1954, which provides for the setting up of an Atomic Energy Authority for the United Kingdom, in accordance with the recommendations of Lord Waverley's Committee (see *Nature*, 173, 459; 1954), received Royal Assent on June 4. In the debates in Parliament, concern was freely expressed as to the position of the employees of the proposed Authority, particularly in regard to the security regulations suggested in the original first schedule. When the Bill was debated in the House of Commons, satisfactory words could not be found to define the grounds on which an employee of the Authority would be referred to the purge tribunal as a bad security risk. Such a definition was needed to write into the Bill safeguards for requiring the Lord President's consent to dismissal if the tribunal should recommend it and if the Lord President agreed with it. None of those who spoke in the debate liked the reference to a man's political associations, and in the Committee stage in the House of Lords on May 19 Lord Salisbury accepted on behalf of the Government an amendment by Lord Silkin which avoids the use of these words. In accordance with this amendment, Section 4 of the First Schedule of the Act reads: "Except with the consent of the Lord President of the Council, the Authority shall not terminate on security grounds the employment of any officer of, or person employed by, the Authority. In this sub-paragraph the expression 'security grounds' means grounds which are grounds for dismissal from the civil service of Her Majesty, in accordance with any arrangements for the time being in force relating to dismissals from that service for reasons of national security". This amendment, which puts employees of the Authority in exactly the same position as Civil servants, was afterwards welcomed by Mr. G. R. Strauss on behalf of the Opposition as perfectly satisfactory, when the Lords' amendments were considered in the House of Commons on May 31, and was accepted by the House with other amendments.

At the third reading in the House of Lords on May 27, Lord Salisbury, in reply to questions from Lord Stansgate and Lord Jowitt, explained that the Estimate to be submitted to Parliament in accordance with Clause 4 of the Bill would be in two parts. The first part would cover the expenses of the small office which will assist the Lord President to discharge his atomic energy function. The second, covering some 99 per cent or more of the total, would represent the money which the Lord President would pay over to the Authority. It would be broken down under a number of headings, though the information would be rather less detailed than is usual in regard to an ordinary departmental Vote, having regard both to the need for security and to creation of a body with freedom to run its own day-to-day affairs. The exact form of presentation, said Lord Salisbury, is still being discussed, but the breakdown will not permit a distinction to be drawn between expenditure for civil purposes and expenditure for defence. For security reasons, moreover, sums included in the Ministry of Supply and Service Department Votes for payments to the Authority for work on atomic weapons will not be shown separately, but the degree of parliamentary control provided under the clause is substantially greater than has existed in the past. Referring to the importance of a proper balance of the use of atomic energy between military and civil purposes, Lord Salisbury said that this is a major reason for transfer of responsibility from the Minister of Supply to the Authority. At present none of the energy which will be created will be allocated to private industry; it will all be in the hands of the British Electricity Authority, which ultimately will transmit the electrical power to industry.

Queen Elizabeth House : a New Centre in Oxford for Colonial Studies

A NEW centre for Colonial studies is to be established in Oxford under the joint auspices of the Colonial Office and the University, and H.M. the Queen has been graciously pleased to allow it to be named Queen Elizabeth House. For some time past it has been obvious that the cultural, economic and social life of the overseas territories of the British Commonwealth for which the United Kingdom Government is responsible has been changing very rapidly, and it is imperative that relationships between the people of these territories and those of the United Kingdom (and of the Commonwealth generally) be adjusted in harmony with these changing conditions. Much has already been done by university studies and cultural contacts promoted by government and other bodies; but what has hitherto been lacking is some recognized centre, associated with the many bodies and institutions at work in this field, but not designed to supplant or interfere with their various activities. To this centre students and visitors from overseas, together with persons in Britain concerned with the problems facing the oversea territories, could come for free discussions with others who share their interests and be put in touch with those who can help them in their studies. Such a centre, in addition to the services which it could render to individuals, could provide a setting for conferences and summer schools as well as for more formal courses arranged by government or other authorities for men and women working, or intending to work, overseas. To perform these functions effectively, the centre would have to be residential and located in suitable academic surroundings.

Recently, Sir Ernest Oppenheimer offered £100,000 to the University of Oxford for the development of Colonial and allied studies, on the understanding that a centre of the kind described above would be established in close connexion with the Institute of Colonial Studies already existing in Oxford, though not exclusively linked to it in such a way as would prevent the fullest co-operation with other interested bodies. In recognition of the important part which such a centre could play in the training of Colonial Civil servants and other cognate activities, the British Government has promised a contribution towards building costs of up to £50,000 from Colonial Development and Welfare Funds. The University of Oxford is now co-operating in securing a suitable site and in establishing the centre upon it. In order that the centre may be brought into being as soon as possible, arrangements are being made for constituting a governing body on which official, academic and other interests will be represented.

New Nature Reserves in Britain

Two further nature reserves were declared on June 15 by the Nature Conservancy. The first of these consists of the Huntspill River and Huntspill sea-wall area of about 300 acres and roughly 6,000 acres of tidal mud flats near the mouth of the River Parrett in Bridgwater Bay. Steart Island will be added by a further declaration on the expiry of the existing tenancy over it next year. The mud flats are the scene of a most successful experiment in harnessing vegetation to the work of coastal defence: the introduction of *Spartina townsendii* considerably raised the foreshore-level and gave effective protection against incursions by high tides. Further experiments are planned by the Conservancy in collaboration with the Somerset River Board. The flats are also of great ornithological interest as a roosting place for wildfowl, including wild geese, and for waders, forming the only gathering ground for moulting shelducks in Great Britain. The discontinuance of existing shooting rights will provide a large sanctuary area in which wildfowl and waders can feed and roost undisturbed and build up stocks of these species.

The second new reserve, Castor Hanglands, is in the parishes of Ailsworth and Marholm, four miles west of Peterborough. It consists of 12½ acres of mixed woodland, known as the Blacklands, and about 93 acres of rough grassland and bushes called Ailsworth Heath, which was originally recommended as a nature reserve in 1947, particularly for the rich insect life and wide range of plant life to which the soils derived from oolitic limestones and calcareous clays give rise and of which few examples remain. There are two small pools in the reserve which support a variety of aquatic vegetation, and the heaths and woodlands harbour the rare butterflies, the black hairstreak (*Strymon pruni*), the large tortoiseshell (*Nymphalis polychloros*) and the chequered skipper (*Carterocephalus pakeman*). Access to Blacklands will be by permit; but there will be no restriction on public access to Ailsworth Heath, though permits to collect will be required.

Ethnology of Saipan in the Mariana Islands

IN Vol. 14 (anthropology) of *Fieldiana* (pp. 384; Chicago Natural History Museum, 1954; 5 dollars), Alexander Spoehr discusses Saipan in the Mariana Islands, and describes Spanish, German, Japanese and recent American rule in those islands. The

Japanese sent many immigrant settlers there and built up an extensive sugar-cane industry between the two World Wars. The destruction of industry in the Second World War was complete. Saipan was an area of intense battle in which 23,811 Japanese military were killed and 1,810 taken prisoner, while the Americans lost 3,144 killed in action and 11,000 wounded. The ethnology is a description of the changing customs and habits of some Chamorro and ex-Caroline islands natives who live in Saipan.

Symposium in Dublin on Peat

An international symposium on peat will be held in the College of Science, Merrion Street, Dublin, during July 12–17, under the auspices of the Bord na Móna, the statutory corporation set up by the Republic of Ireland to develop the peat resources of the country. On the first day, after the formal opening by the Minister for Industry and Commerce, peat resources and development in each of the following countries that will be represented at the symposium will be discussed: Canada, Denmark, England and Wales, Finland, France, Germany, Northern Ireland, Netherlands, Norway, Republic of Ireland, Scotland and Sweden. Subsequent sessions will deal with the following topics: methods of survey; general and technical classification of peats; milled peat; sod peat; dehydration; large- and small-scale plants for utilization of peat; use in gas turbines; peat coke and wax; gasification; and reclamation (afforestation, and also agriculture and soil conditioning). An excursion will be made to the Bord na Móna works. Further information can be obtained from the Bord na Móna, 28 Upper Pembroke Street, Dublin.

International Union of Geodesy and Geophysics

In connexion with the tenth General Assembly of the International Union of Geodesy and Geophysics to be held in Rome during September 14–25, the sponsoring body, the Italian National Research Council, is organizing an exhibition, to be held in the same building as the Assembly meetings, of geodetical and geophysical instruments and equipment. The exhibition will be open to the public during September 13–25. Completed application forms, which can be obtained in Britain from the Assistant Secretary, Royal Society, Burlington House, London, W.1, must be sent by July 15 to the following address: Consiglio Nazionale delle Ricerche, Mostra internazionale di geodesia e geofisica, Piazzale delle Science, 7 – Roma (Italia).

Announcements

Sir Frederick Brundrett, deputy scientific adviser to the Ministry of Defence, formerly chief of the Royal Naval Scientific Service, has been appointed chairman of the Defence Research Policy Committee in succession to Sir John Cockcroft, who has been appointed to the board of the new Atomic Energy Corporation as director of the Atomic Energy Research Establishment.

The President of the Board of Trade has reappointed Sir Percy Mills as chairman of the National Research Development Corporation and Prof. P. M. S. Blackett, Sir John Duncanson, and Sir Edward de Stein as members for a further period. Sir Henry Hinchliffe and Sir Alan Saunders are also appointed members in succession to Sir Edward Hodgson and Mr. W. E. P. Johnson, who are retiring.

Sir John Russell has been elected a foreign member of the Académie d'Agriculture de France in succession to the late Prof. Winogradsky.

Prof. H. R. Robinson, emeritus professor of physics at Queen Mary College, has been elected vice-chancellor of the University of London for the remainder of the present session and for the session 1954–55, in succession to Sir Roderic Hill, who has resigned on medical grounds.

Dr. S. Whitehead, director of the Electrical Research Association, has been elected chairman of the Committee of Directors of Research Associations.

The Institution of Production Engineers will be holding an exhibition and conference in London at the National Hall, Olympia, during July 7–14 (closed on July 11). Besides displays by industry on production engineering research and materials, equipment and apparatus which contribute to productivity, the exhibition will contain a number of items illustrating the work of the Department of Scientific and Industrial Research, the research associations, and government departments and other institutions. The conference will consist of morning and afternoon sessions on each day of the exhibition, except July 10, when papers on various aspects of the problems of increased productivity—technical, psychological, physiological, etc.—will be read. Applications for tickets to the exhibition or conference should be made to Andry Montgomery, Ltd., 11 Avenue Chambers, 4 Vernon Place, London, W.C.1; further details can be obtained from the Secretary, Institution of Production Engineers, 10 Chesterfield Street, London, W.1.

Mr. G. Seligman, president of the British Glaciological Society, writes: "With reference to the obituary notice of Prof. A. B. Dobrowolski in *Nature* of June 12, Mr. E. Gold mentions that his great work on ice, "The Natural History of Ice", was published in Polish. However, two of the most important chapters of this work, namely, 13 and 14, were translated into English by Prof. B. W. A. Massey, of the University of Poznan, and were published in 1943 under the title "Glaciers: Structure and Movement Theories", by the Institute of Experimental Physics, Warsaw, as Supplement No. 1 to the *Bulletin of the Polish Geophysical Society*, Part 16 (Warsaw, 1939–48)".

The directors of Griffin and Tatlock, Ltd., and of W. and J. George and Becker, Ltd., have announced the merging of their two organizations, under the name of Griffin and George, Ltd. Griffin and Tatlock, Ltd., with their associated company, Standley Belcher and Mason, Ltd., manufacture scientific apparatus and laboratory furniture in London and Birmingham, and have branch houses in Manchester, Sheffield, Glasgow and Edinburgh. Griffin and Tatlock (India), Ltd., operates from Calcutta and Bombay. The name of the firm, which originated in 1826, is widely associated with laboratory apparatus under the trade mark 'Microid'. W. and J. George and Becker, Ltd., of London and Birmingham, have manufactured laboratory equipment since 1897. The original firm of F. E. Becker and Co. was founded in 1872, and was purchased by W. and J. George, Ltd., in 1897. The company produces an extensive range of products including optical and electrical apparatus and high precision balances, which are sold under the trade mark 'Nivoc'. The chairman of the new company of Griffin and George, Ltd., is R. McKinnon Wood.

FIFTH INTERNATIONAL WEST AFRICAN CONFERENCE

SCIENTISTS working in the several territories of West Africa were long hampered by lack of opportunities for contact with one another. Contiguity of territory enabled the French to extend much of their work over the whole or greater part of French West Africa; but studies in the separate British, Spanish and Portuguese areas lacked correlation. A very important function is thus served by the International West African Conference, which meets every second year, alternating between British, French, Spanish and Portuguese territories. The fifth conference was held at Abidjan (Côte d'Ivoire) during December 7–10, 1953, followed by excursions during December 11–19. Difficulties of accommodation, not the least being space on air lines, necessitated the participation being restricted to official delegates; but those present represented a wide range of interests and regions.

The conference met under the presidency of Prof. G. Mangenot, director of the Institut de Recherche Scientifique et d'Études Tropicales of the Office de la Recherche Scientifique Outre-Mer, and most of the meetings were held at the Research Station of the Institut at Adjopodoumé some 18 km. from Abidjan. Other meetings were held at the Museum and Research Station in Abidjan of the Institut Français d'Afrique Noire, the headquarters director of which is Prof. Th. Monod (Dakar). The smooth running of the conference owed everything to the organizing ability of M. J. L. Tournier, of the Institut Français d'Afrique Noire, who acted as secretary.

Delegates included a dozen from British West African territories and two from Britain (Profs. C. Daryll Forde and L. Dudley Stamp), and the conference opened with a gathering at the Palace of the Governor, followed in the evening by a brilliant and lavish reception at Adjopodoumé attended by leading citizens, both African and European, of Abidjan.

The working sections were those of zoology, botany (including forestry), geography (including geology) and ethnology–sociology (including economics). For some sessions the last two met jointly, and papers of general interest were read to plenary meetings.

It would be difficult to speak too highly of the lavish hospitality of the French hosts. A conference where delegates have no need of money at all, their every wish being anticipated by a system of vouchers, must be almost unique. The insight given into the cultural life of a remarkable tropical city with fourteen thousand white inhabitants was a revelation to many of the delegates long familiar only with their own territories. The conference was in other ways ideal in that it gave abundant opportunities for discussion amid delightful surroundings, and local excursions arranged for all interests formed a pleasant prelude to the two long excursions. Of the latter, one studied the ecology and forestry of the coastal belt, and the other undertook the long journey across to the Liberian border and the eventual ascent of the massif of Nimba.

The conference revealed in a striking way the large volume of fundamental research now in progress in West Africa. In the French territories this is now focused by the Institutes; in the British territories the influence of the University Colleges of the Gold Coast and Ibadan is very marked. Young enthusiastic scientists, not overburdened with routine teaching, are bringing to bear on African problems techniques acquired in universities all over the world. At present, those of European descent play the leading part; but Africans are beginning to take their places in the ranks of the research workers. Detailed studies ranging from the distribution of population, so bafflingly irregular, and the ecology of disease to the measurement of evaporo-transpiration and the economics of fisheries cannot fail to throw light on the innumerable problems which at present hinder the development of tropical Africa and at the moment make nonsense of 'planning'.

L. Dudley Stamp

THE GOLGI APPARATUS

SYMPOSIUM OF THE ROYAL MICROSCOPICAL SOCIETY

ON May 5 the Royal Microscopical Society held a symposium on "The Golgi Apparatus". The opening address was made to a large gathering by the chairman for the morning session, Dr. L. Foulds, who directed attention to the present controversy regarding the intrinsic morphology of the Golgi apparatus.

The first speaker was Prof. J. Brontë Gatenby (Trinity College, Dublin), who expressed his gratitude to the Society for its recent award to him of an honorary fellowship. He then went on to review the various controversies which have been in vogue concerning the morphology of the Golgi apparatus. The most important controversy of all, he said, arose with the vacuome theory of the Parat school (1924–33); but this work has been discredited by many cytologists. It is significant that Parat's term 'lépidosome' instead of 'dictyosome' has not been used in the new great French text-book "Traité de Zoologie". With regard to the recent controversial views, held mainly by the Oxford school, Prof. Gatenby said that on the whole, apart from their use of Parat's word lepidosome, he is in agreement with much that they have written about the structure of the Golgi apparatus of invertebrate cells. However, he cannot accept the view that the Golgi apparatus or network of vertebrate neurones is an artefact. Both Dr. T. A. Moussa and he have seen the network in living neurones, and this has been confirmed by the vital observations of the Americans Adamstone and Taylor. Similar networks have also been seen in living cells of the epididymis by Dr. A. J. Dalton and Mrs. M. Felix. In addition, these latter workers have supplied him with some remarkable electron micrographs which agree with his conception of the networks as being a series of vacuoles, compressed spaces and canals, to the walls of which a chromophile substance is attached.

Finally, Prof. Gatenby gave seven reasons why he believes that the Golgi dictyosomes of invertebrate cells may be regarded as being homologous with the

Golgi networks seen in vertebrate cells. These inclusions occupy similar positions in the undifferentiated cell; play an important part in cell secretion; can be shown by the classical technique; have the same specific gravity when ultracentrifuged; unless dispersed are attached to the centriolar part of the amphiaster at some stage in cell division; cannot be vitally stained in neutral red and methylene blue; and both have the same dictyosome-like appearance in amphibian nerve cells.

After the long paper by Prof. Gatenby, two shorter papers were given by Dr. G. H. Bourne (Department of Histology, London Hospital Medical College) and Dr. A. L. Roque (Department of Zoology, Oxford). Dr. Bourne concentrated on some chemical and biochemical aspects of the Golgi region of certain cells, and pointed out that there is good evidence to suppose that such regions, and therefore possibly the Golgi apparatus, contain lipoidal substances and polysaccharide. Also, in some cells of the adrenal cortex there is a localization of ascorbic acid which corresponds with the position usually occupied by the Golgi apparatus. There is also good evidence to suppose that the Golgi apparatus of the epithelial cells of the small intestine contain alkaline phosphatase and some other phosphatases, including one which dephosphorylates œstrogen phosphate. The epithelial cells of the mouse prostate also contain acid phosphatase in the Golgi region. Dr. Bourne concluded that these results indicate that the Golgi region, or Golgi apparatus, is of considerable biochemical importance.

Dr. Roque made a report on a detailed study of the form of the lepidosomes (dictyosomes) in the male germ-cells of *Helix*, as revealed by phase-contrast and interference microscopy and by the use of vital dyes. He compared these lepidosomes with the lipochondria of the nerve cells of *Helix* and showed that they are distinct morphologically.

For the afternoon session, the chair was taken by the president of the Society, Dr. T. E. Wallis. Each of the four speakers in this session were from the Department of Zoology, Oxford. The first paper was read by Mr. S. A. Shafiq, who said that in the neurones of *Locusta migratoria* Kolachev preparations reveal the Golgi apparatus as a number of curved rods (dictyosomes) scattered about the cytoplasm. When lipid preparations are made the lipid appears in the form of spheroids also scattered about the cell. In order to see if any relationship exists between the two inclusions, Kolachev preparations were made, but were osmicated for only a short time. Faintly impregnated dictyosomes were seen. On colouring these sections with sudan black it was apparent that the dictyosomes were a deposit of osmium on the curved surface of the lipoidal spheroids. Further proof for this view has been adduced by a study of the developing neurone. As a result of this work, Mr. Shafiq pointed out that the dictyosomes of these invertebrate neurones, being an artefact, cannot be homologized with the Golgi apparatus of vertebrate neurones.

The next paper was read by Dr. W. G. Bruce Casselman and dealt with the histochemistry of the sites in certain cells where osmium tetroxide or silver nitrate are reduced in classical Golgi methods. The study was based on the work of Mr. Shafiq and Dr. John R. Baker, who found that the classical methods when used on the motor neurones of *L. migratoria*, and intestinal epithelial cells and Paneth cells of the mouse, were impregnating mainly lipoidal bodies. Dr. Casselman said that in the motor neurones the lipochondria (= lipoidal bodies) consist principally of phospholipids and cerebrosides. In the intestinal epithelial cells of the mouse, the lipochondria apparently contain only neutral lipids and are embedded in a neutral mucopolysaccharide. The lipoidal bodies of the Paneth cells are embedded in what is probably a mucoprotein and, in addition, are at least partly covered by neutral lipid.

The next speaker was Dr. John R. Baker, who said that a single name can be properly given to an object in a cell if there is reason to believe that it always has essentially the same structure and always essentially the same chemical composition. This does not apply to the term 'Golgi apparatus'. Not only were the 'Golgi dictyosomes' studied by Mr. Shafiq an artefact, but also they were morphologically different from the 'Golgi networks' which Dr. Baker himself had examined in vertebrate neurones. He believed, too, that these networks are an artefact produced in neurones by the over-impregnation of lipochondria. In gland cells a similar network may be an artefact of a different kind, for it may simply result from the deposition of metals on chemically modified cytoplasm between crowded secretion granules. A special study on the intestinal epithelial cells of the mouse had shown that the 'Golgi apparatus' of these cells is an artefact formed by the deposition of osmium on to the lipochondria. Dr. Baker then emphasized the work of Dr. Casselman as showing the lack of specificity of the classical Golgi methods which may reveal 'sites' of dissimilar chemical composition. He urged the discontinuance of the term 'Golgi apparatus', for there cannot be any homology, as the term implies, between objects or regions which differ both structurally and chemically. Further emphasis was placed on the unsuitability of the term 'Golgi substance', for Dr. Baker pointed out that it means nothing to anyone with a biochemical outlook.

The last paper of the afternoon was read by Dr. A. J. Cain, who discussed mainly the concept of homology at intracellular levels. He indicated that, in view of what had already been said by other Oxford workers, objects lumped under the term 'Golgi apparatus' may have been wrongly homologized due to the imperfections of the classical technique.

The chair for the evening session was taken by Dr. R. J. Ludford, and the one paper at this session was read by Mr. Dennis Lacy (Department of Zoology, St. Bartholomew's Hospital Medical College), speaking on the Golgi apparatus of the exocrine and endocrine cells of the pancreas of the mouse. He showed that the various distorting effects which the classical fixatives are supposed to have on the lipoidal bodies are erroneous, and also that the Golgi network of these cells do not result from either the over-impregnation of lipoidal bodies or from the laying-down of metals between secretion granules. Emphasis was placed on the delicate appearance of the networks of these cells as shown by Nassanov, Morelle, Gatenby, Ludford, Hirsch, Bensley, Beams and other distinguished cytologists. None has produced gross over-impregnated structures. The network of these cells was then shown to be a net-like canalicular system, distinct from lipoidal bodies, neutral-red granules or mitochondria. These canals were shown by Mr. Lacy after the use of a variety of fixatives, in frozen-dried preparations and in living cells.

Dr. Ludford then opened up the meeting for discussion. Many interesting points were raised, among which was a question by Dr. A. J. Marshall as to whether the Oxford workers had at any time, in their numerous preparations, seen a canalicular structure. Dr. Baker said that Dr. W. S. Morgan (late of Oxford) had seen the canals in fixed preparations of acinous cells of the pancreas; but that he [Dr. Baker] could not say whether or not they existed, though he could say that they should not be called Golgi bodies.

The main issue which emerged from this symposium was whether or not the term 'Golgi apparatus' (or 'Golgi body', etc.) should be used. According to the Oxford workers it denotes homology between objects believed by these workers to be mainly artefacts, the true form of which is represented by lipoidal bodies which may differ chemically from one another. The Oxford work is, however, based mainly on the results of one invertebrate cell (the neurones of *L. migratoria*) and on two kinds of intestinal cells (epithelial and Paneth). Further, their artefact theory probably cannot be accepted in at least four very different kinds of vertebrate cells (neurones, exocrine and endocrine cells of the pancreas, and epididymis cells), where the evidence from so many sources (fixed, ultracentrifuged, frozen-dried, electron microscope studies and vital examination) leaves little doubt that the Golgi network does exist in life. This latter work shows clearly, too, that the network is not represented by lipoidal bodies, and all the Oxford studies emphasizing chemical dissimilarity are studies on the lipoidal bodies. It is clear that such lipoidal bodies may not be homologous. From the classical point of view, Prof. Gatenby has given seven reasons why he accepts homology between the Golgi dictyosomes of invertebrates and the Golgi network (or canals) of vertebrates and retains the general term Golgi apparatus. The crux of the matter is whether, as yet, there is sufficient evidence of an incontrovertible nature, on a large enough number of invertebrate and vertebrate cells, to justify a change in nomenclature which will affect some two thousand papers.

A full account of the symposium and the discussion which followed will be published in the *Journal of the Royal Microscopical Society*.

DENNIS LACY

THE IMMOBILIZATION OF MINERAL NUTRIENTS IN TROPICAL SOILS

MESSRS. W. V. Bartholomew, J. Meyer and H. Laudelout, of the Institut National pour l'Étude Agronomique du Congo Belge (I.N.E.A.C.), have published a paper which should be of considerable interest to all who are concerned with the underlying causes of fertility and infertility of tropical soils (*Publ. I.N.E.A.C.*, Sér. Sci. No. 57, 1–53, 1953; 30 f.). They have tackled the problem of the immobilization of mineral nutrients under forest and grass fallow in the Yangambi region of the Belgian Congo, and they have given some attention to the decomposition of plant debris on the forest floor. Some understanding of these matters is essential to rational agricultural practice, especially in those regions where the inherent soil fertility is not very great, where it may be of a fleeting character, or where it may indeed be almost incredibly low. In the native rain forest a large proportion of the available plant nutrients is immobilized in living organisms —mostly forest trees and vines—but large quantities of plant tissue (mainly leaves and branches) are constantly being deposited on the forest floor, where they decompose and return their nutrient content to the soil. The reabsorption of these nutrients by elements in the flora and fauna is so rapid in the rain forest that, in the case of an acid sandy soil which was studied, the available supply in the soil was found to be continually kept at an exceptionally low level. The authors consider that under a plant cover with high nutrient demands, it is unlikely that many nutrients are lost by fixation or leaching.

When a forest is felled and a crop established, the transition phase is often attended by the temporary liberation of large quantities of mineral nutrients to the soil and by an accelerated loss of nitrogen, particularly if the area is burned over, as is frequently the contemporary practice. In such instances there may be a considerable, even a high, loss of plant nutrients before the crop has grown sufficiently to re-immobilize most of them. In the usual cultivation practices, however, the new crop is typically established concurrently with the disintegration and decomposition of the forest debris; but even so the utilization of all the nutrients may not keep pace with mineralization, and excessive nutrient losses may result.

Native cropping practices in the Central Congo Basin usually permit the return of forest species within 2–3 years after the forest is felled, and the ensuing fallow or regeneration period may continue for about fifteen years, where there is government supervision; but it may be considerably less. While this kind of soil management has its defects both in terms of soil fertility and labour, it "appears to be a practical solution to the soil management problems where land is in good supply, demand is not great for agricultural products, transportation to market and supply is long and costly, and where local fertilizer resources are either non-existent or not developed".

In both forest and grass fallow the authors point to two factors as being of first importance in enhancing soil fertility, namely, the accumulation of nutrients in organic combinations and the prevention of their loss by plant immobilization, and the improvement of soil structure by rest from cultivation and by biological activity.

The use of grass fallow as an alternative for short rotations has been considered, but its value in native agriculture requires fuller exploration. The maximum usefulness of grasses as fallow crops is probably attained within a few years. It has been observed that after two to four years the rate of root formation reaches a maximum and that decomposition of the grass residues proceeds as rapidly as the new growth is formed; that is, a maximum immobilization of plant nutrients in organic form has been attained. Thereafter, the chief effects of an extension of the fallow period would be to improve the soil texture.

As the immobilization of mineral nutrients may be the most important means of evaluating the usefulness of fallow systems, an investigation was carried out to obtain some indication of the actual amounts of nutrients immobilized under forest fallow con-

ditions after different periods of time and to compare the effects of grass and forest fallows. The sites selected for sampling in the more mature forest fallow areas were approximately 10 × 30 metres. All the vegetation of suitable and representative sub-plots was collected and weighed green at the site, leaves being separated from branches and trunks from roots. Samples of these materials were duly analysed for their water, mineral and organic contents. Litter samples, subdivided into foliar and stem materials, were similarly analysed. Grass samples were taken from replicated plots of different species representative of fallow areas. It was found that the immobilization of nutrients in the forest fallow is initially rapid: in the first five years more than half the total amount immobilized in eighteen years is accounted for. Leaf growth rapidly approaches a maximum, the later increases in total growth being chiefly due to the accumulation of woody materials, especially in the aerial parts. Roots also approach a maximum at a rather rapid rate. The data at five years show 75 per cent as much growth as at eighteen years. Litter accumulation from leaf and stem residues approaches a maximum some time between eight and twelve years.

In grass fallows, it was noted that a large part of the total harvested material consisted of litter in various stages of decomposition, this being in sharp contrast to either the quantity or proportion of litter in the forest fallow plots. The total root weight in the grass fallows was considerably less than in the forest fallow, though the small and fibrous character of grass roots must here be borne in mind.

The distribution of the nutrients in the different plant parts is important. Thus, leaves comprise only a small proportion of the total weight of plant material except during the early stages; woody tissues, of both stems and roots, account for most of the total weight. In the immobilization of nutrients, however, leaves are considerably more important than woody tissue, particularly in the uptake and release of nitrogen. The woody tissues contain the major proportion of all nutrients, except in very early stages of the fallow, and are particularly important as repositories of the cations and phosphorus.

In the grass plots, it was found that the litter contained a large proportion of the plant nutrients, the roots accounting for only 10–20 per cent. Also, grass is relatively higher in phosphorus and potassium and lower in calcium and magnesium than forest fallow. In the investigators' view, for short fallow systems, the grass fallow compares favourably with the forest fallow, in that it appears to absorb nitrogen and phosphorus at a more rapid rate in the early stages of development. It could not, however, be expected to immobilize the large total quantity of nutrients found in a mature forest fallow.

The rate of nutrient release from fallow forest residues after clearing for cultivation was not specifically studied; but estimates based on the data of decomposition experiments and on a knowledge of mineralization processes of plant materials yield some points of considerable practical importance. Burning of forest fallow or grass fallow releases the immobilized nutrients immediately, a large proportion of the bases (potassium, calcium, magnesium, etc.) and phosphorus being deposited as the oxides on the soil surface; nitrogen, on the other hand, is almost totally lost into the atmosphere, either as free nitrogen or as volatile oxides. After burning, it is, of course, the availability of nutrients that is of special interest and this may present problems of some complexity. Thus, the phosphorus may be partly fixed in relatively unavailable form before the newly planted crops can absorb it; and potassium may be fixed, or lost through drainage. The available nitrogen, on the other hand, because of its release from immobilization in the woody tissues, may be higher immediately after burning than where the vegetation is simply allowed to decay. In general, if the fallow vegetation cover is not burned, its nutrients will tend to be retained in organic combination until they are released by the action of micro-organisms. The major part of the nitrogen, phosphorus and other mineral nutrients is rapidly liberated in mineral form, but, simultaneously, these are taken up again in the synthesis of the cellular materials of the invading micro-organisms. The net difference between mineralization on one hand and this new immobilization on the other gives a measure of the nutrients available for use by crop plants. During vegetable decomposition, potassium and phosphorus are lost more rapidly than nitrogen. In plant residues and in micro-organisms, the ratio of nitrogen to phosphorus approached 7–8 : 1. In soil organic matter Pearson and Simonson found ratios ranging from 7·0 : 1 to 15·7 : 1 with a mean of about 9·3 : 1. The authors record that the litter from the forest fallow plots, and litter gathered from the native forest, had a nitrogen to phosphorus ratio of about 25 : 1. In the residue from the decomposition of the mixed forest leaves the ratio was 32 : 1, and in the decomposed litter from the grass plots it was 12 : 1. They consider that it is unlikely that nitrogen could be rapidly liberated during the initial stages of decomposition of forest or fallow vegetation, as the organisms causing decomposition will initially re-absorb a part of it. Hence, burning the fallow vegetation may actually result in a better nitrogen supply during the early stages of utilizing forest or fallow land than natural decomposition after felling but without burning.

The release of phosphorus from decomposing vegetation is likely to be more rapid than that of nitrogen; and potassium, calcium and magnesium should be rapidly released because of their relatively low utilization in the metabolism of micro-organisms. In the case of potassium this rapid loss was demonstrated experimentally. But calcium and magnesium, though they are liberated and made available, form various insoluble salts, for example, carbonates, sulphates and phosphates. They are not removed by leaching and remain as a part of the decomposed residue. This property makes difficult the measurement of mineralization. The authors conclude that mineralization of nitrogen and phosphorus from grass fallow will, in general, be more rapid than from forest fallow. Potassium from grass fallow will be similar to that from forest fallow, but in each case the rate of release would be related to the total quantity immobilized. Calcium and magnesium were found to be low in the grass samples examined and therefore are not likely to be supplied rapidly from such fallow systems. They also point out that the decay of forest residues may not provide a balanced nutrient supply for some crops and that the relative concentration of available nutrients may undergo important changes during the course of the decomposition; for example, nitrogen may be immobilized to a much greater extent than the other nutrients. The liberation of the elements through biological

decomposition is a slow process and in 4–6 months forest fallow residues may yield no more than 30 to 50 per cent of the total potassium or calcium and magnesium, and 15–30 per cent of the total phosphorus, while the percentage release of nitrogen may be even smaller.

TOBACCO RESEARCH BOARD OF SOUTHERN RHODESIA

NEW HEADQUARTERS STATION AT KUTSAGA

By Dr. F. A. STINSON

Director of Tobacco Research, Southern Rhodesia

TO solve the production problems of the expanding tobacco industry in Southern Rhodesia, the growers and Government jointly established in 1950 the Tobacco Research Board. Interest and confidence of growers in results of research have been considerable, owing to their representation on the Board and to the direct financial contribution they make toward it—more than £2 for every £1 provided from general taxation.

The Board's research approach is agronomic in its broad sense, and the investigations on crop rotations serve to illustrate this. Comprehensive rotation experiments were developed owing to the inadequacy of systems of cropping used on farms in all tobacco-growing areas. Their design permits comparing the effects, on yield and quality of tobacco, of growing many different crops in various sequences with a range of fertilizer practices, management and methods of crop disposal. Study of crop nutrition, soil organic matter and methods of disease, insect and eelworm control is also an integral part of these projects.

Experiments of lattice and factorial designs are used extensively to examine effects of inter-related production factors. Simultaneous examination of the important factors bearing on a specific problem has helped to minimize the dissipation of energy which would otherwise result if, in evaluating methods of controlling a leaf spot disease, for example, such important factors as date of planting, soil fertility and the effects of cropping systems on eelworm incidence were overlooked.

The excessive drainage and excellent aeration that make Rhodesian sandvelds so suitable for flue-cured tobacco pose special problems in humus replenishment and fertility maintenance. The abundance of available nutrients required for rapid growth and economic yields, along with the sensitivity of leaf quality to changes in nutrient balance, give nutritional research—both in the field and in the laboratory—a high priority in the programme. Present fertilizer investigations include examination of rates of use and sources of nitrogen, phosphorus, potassium and magnesium. Methods of fertilizer placement and the efficiency of nitrogen and potassium when applied fractionally, as well as responses to trace elements applied singly and in combinations, are being examined. Disease, insect and eelworm control investigations occupy an important place in the Board's work. Methods of producing tobacco seedlings, as well as cultural and curing practices, receive attention. The varietal improvement work includes testing and comparing the ability of particular varieties to produce high quality and yield, as well as evaluating their resistance to various diseases and types of eelworm damage. Breeding work in progress is designed to introduce resistance or immunity while, at the same time, further improving the leaf qualities of those varieties now in common use for commercial production. By introducing improved varieties, materials and methods as standard treatment in all field experiments as soon as their superiority is indicated by research, such factors are proved on a farm scale before being offered to farmers in the form of recommendations.

The procedure in laying out field experiments has been standardized within the organization. Fields are divided into ranges and permanently benchmarked to accommodate 60-ft. rows of tobacco. Plots differ in width only; the number of rows per plot varies from one to eight, depending on the nature of the experiment. A permanent system of roadways and surface drainage is provided by placing the 60-ft. wide ranges 25 ft. apart, each intervening strip consisting of a broad-based terrace and a broad, shallow channel. The direction of ranges to field slope is adjusted so that the fall in the rows of tobacco and in the drainage channels ensures surface drainage without causing erosion. Ant-heaps up to 100 ft. in diameter and rock outcrops, common in Rhodesian tobacco-farming districts, complicate the siting of field experiments.

An important stage in the organization's development was marked by the formal opening of the Kutsaga Station on January 21 this year. This Station, which is near Salisbury, is now the headquarters of the Tobacco Research Board. Before Kutsaga was established, the Trelawney Station, opened by the Government in 1934 and leased to the Board in 1950, was the centre of tobacco research, and it will be operated in future as a branch station.

Kutsaga occupies 585 acres alongside the new national airport, ten miles south of the Federal capital. The research building provides spacious chemical and biological laboratories, a library, staff canteen and stores; the addition of two laboratory wings is anticipated. The laboratories are fitted with electricity, gas and hot and cold water. The Cape-Dutch design of the building blends with its natural surroundings of indigenous trees on a sandy slope typical of those in much of the tobacco-growing region. The slate roof, the teakwood terrazzo floor and the mukwa panels and fittings are in keeping with the importance of the country's largest industry which the Board serves. At the rear of the main building is a 100-ft. greenhouse and headhouse containing a laboratory and storage and potting room. Farm buildings for handling, curing and grading leaf from experimental plots were ready for the 1953–54 crop. Modern residences have been erected on the Station for key staff members, and substantial brick homes, with modern plumbing and sanitation, are being provided for all African employees and their families.

Staff are encouraged to obtain postgraduate experience outside Rhodesia, the Board's paid study-leave scheme being designed to facilitate this advanced training. There are also bursaries to assist above-average Rhodesian students to qualify at leading universities preparatory to employment by the Board. At present the Board has a professional staff of fifteen, including a biometrician.

The Board is aware of the importance of keeping the sponsors, especially tobacco growers, fully informed on the progress made. The frequent publication of reports of progress, bulletins and interim

reports, as well as the preparation of material for the Press and radio, is regarded as an integral part of the work. The new facilities at Kutsaga will contribute to progress in all branches of the present programme.

The land and buildings at the Kutsaga and the Trelawney Stations have permitted the development of research on most phases of tobacco production. More than four thousand plots were employed in the field experiments during the 1953–54 season. Lack of research information previously retarded development of Southern Rhodesia's flue-cured tobacco industry; but already the growers are extensively adopting with advantage the results of current research.

INDUSTRIAL RESEARCH AND DEVELOPMENT IN THE UNITED STATES

A SURVEY of industrial research and development in the United States conducted in 1952 by the Research and Development Board of the Department of Defense has been issued by the United States Department of Labor*. The report is based on a questionnaire sent to private companies and non-profit research agencies (excluding colleges and universities, as well as hospitals and museums). Some ninety-six thousand research engineers and scientific workers were employed in January 1952 by the two thousand companies which replied, and nearly 75 per cent of these were working for firms engaged in the aircraft, electrical machinery, chemicals and allied products, professional and scientific instruments, machinery (except electrical) and petroleum-refining industries, more than half being employed in the first three of these industrial groups. Two out of three engineers and scientists were on the staffs of companies with five thousand or more employees; but only 1·5 per cent of the employees of the reporting companies were research engineers or scientific workers. About half of them were working on federally financed projects, almost all of which were sponsored by the Department of Defense or the Atomic Energy Commission, and the number so employed was more than 50 per cent higher in January 1952 than in January 1951, although employment on company-financed research increased in most industries during the year. On an average there were 1·5 support workers (technicians and other laboratory assistants, clerical and administrative staff) per research engineer or scientist; but the ratio varied widely between companies and industries.

The annual turnover of this research staff during the year July 1950–June 1951 was 13·9 per cent, or about one-fifth higher than during the last half of 1951, when military service only affected about 3 per cent, although one-fourth of the research staff covered by the study were in the categories most liable to military service, 19 per cent were in the Reserves or National Guard, and another 6 per cent were classified 1 *A* or 2 *A* by Selective Service as of January 1952.

Expenditure of the reporting companies on research and development in 1951 was nearly 2,000 million dollars, compared with a national expenditure on scientific and engineering research and development of about 3,750 million dollars, of which about 2,500 million dollars was for work done in laboratories and other facilities owned or operated by private industry. Of this 2,000 million dollars, more than 1,000 million was spent by the electrical machinery, aircraft and chemical industries, and nearly half of the 1951 research and development expenditure was provided by the Federal Government, ranging from 85 per cent in aircraft manufacture to 3 per cent in petroleum refining. Such research accounted for about three-fifths of the total in companies with less than five hundred employees, compared with about one-half for larger organizations. Research costs amounted to about two per cent of the total value of sales of the reporting companies in 1951, reaching 13 per cent in the aircraft industry but falling to less than 1 per cent in several others. The average cost per research scientist or engineer in 1951 was 21,900 dollars, being lowest in the chemicals and allied products industry and nearly four times as great in the motor-vehicle industry. Taking supporting workers into account, the average cost per research worker was 8,800 dollars, a ratio which varied much less among industries and companies than that for research scientists and engineers.

* Scientific Research and Development in American Industry: a Study of Manpower and Costs. Bulletin No. 1148 of the Bureau of Labor Statistics, U.S. Department of Labor. (Washington, D.C.: Government Printing Office, 1953.) 50 cents.

CAMBRIDGE OBSERVATORIES

REPORT FOR 1953

THE report of the Observatories Syndicate of the University of Cambridge for the year ending September 30, 1953, includes the following headings: reconstruction and re-equipment; solar research; stellar photometry; optics; other investigations; buildings and grounds; lectures; and published papers. The following are the more outstanding items in the report for which there is space in this short article to mention. After exhaustive tests by Drs. H. von Klüber and Z. Suemoto, the spectrograph in the new solar tunnel has been completed and put into use. The grating in the instrument, a modern one lent by the Mount Wilson Observatory primarily for the 1954 eclipse, has proved far superior in general optical quality to any other possessed by the Observatories. The installation of the new 17–24 in. Schmidt telescope which has replaced the Huggins refractor is almost complete, and the telescope is being tested and adjusted. Among the programmes of work proposed for this instrument, an immediate one is the examination and identification of radio sources. The construction of the new 36-in. reflector is continuing, and the firm of Sir Howard Grubb, Parsons and Co. estimates that delivery should take place this autumn.

Solar work is primarily concerned with the problem of the structure of the outer layers of the sun, and in the new solar tunnel Drs. von Klüber and Suemoto have applied a Fabry–Perot interferometer to the measurement of profiles of well-isolated Fraunhöfer lines (in the wave-length region 6200–6400 A.) between the centre of the solar disk and the limb, using a resolving power of about one million. Among other items mentioned, reference may be made to a solar camera of 6 in. aperture and 40 ft. focal length, weighing about 100 lb. with power supplies included, which has been designed by Drs. D. E. Blackwell and D. W. Dewhirst. It is intended to be carried by

a balloon to a height of 60,000 ft. or more, and should turn automatically towards the sun, focus itself and take a series of photographs in practically perfect seeing with the theoretical resolution of a 6-in. telescope. Tests are now being carried out with the camera swinging on a rope attached to a mast, and later tests may be made with the use of a helicopter.

The 15° Selected Areas programme of *pg* and *pv* magnitudes of 1,268 stars, measured photographically and in part also photoelectrically, has been ready for printing since early in the year; but some delay has arisen from the difficulty in finding funds for publication.

Dr. E. H. Linfoot has made an analytical determination of the optimum aberration balancing in aplanats and in astigmats when optical performance, including chromatism, is assessed on the basis of a root mean square criterion of image quality. An account of this work is appearing in his forthcoming book, "Recent Advances in Optics" (Oxford: Clarendon Press). Dr. G. Merton's trials at the Oxford University Observatory of the reconstructed two-plate Schmidt–Cassegrain camera of 8 in. aperture have proved very successful, the smallest fully exposed stellar images being about 15 μ in diameter.

During the year 119 lectures were given by the director, Prof. R. O. Redman, and four other members of the staff, and the Observatory Club held twelve colloquia. The list of published papers includes "A Comparison of the Intensities of Infra-Red and Violet Radiation from the Solar Corona at the Eclipse of 1952 February 25" (*Mon. Not. Roy. Astro. Soc.*, **112**, No. 6, 652; 1952), by D. E. Blackwell; "Den Totale Solformørkelse Den 25 Februar 1952" (*Nordisk Astro. Tidsskr.*, No. 1, 1953), by H. von Klüber; and "The Continuous Spectrum of a Prominence observed at the Total Solar Eclipse of 1952 February 25" (*Proc. Kon. Ned. Ak. Wet.*, **55**, 598; 1952), by R. O. Redman and H. Zanstra.

ASSAY OF TRITIUM-LABELLED SUBSTANCES: A 'COMBUSTION BOMB' METHOD OF PREPARATION OF GAS FOR COUNTING

By P. R. PAYNE and J. DONE

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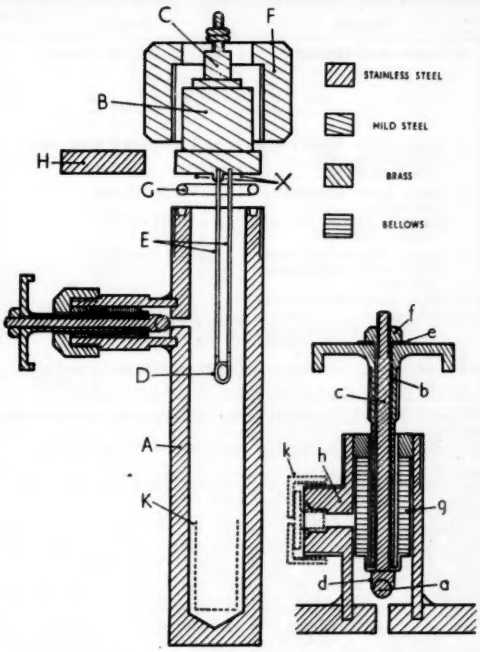
THE estimation of tritium, using the gases generated by the reaction of 'active' water with aluminium carbide as the filling for a proportional gas counter, has been described by White, Campbell and Payne[1]. A method has now been developed which enables the gas to be prepared from tritium-labelled substances in about one hour. Combustion of the samples is effected in oxygen under pressure, in a metal bomb, in which the gas mixture used for counting is afterwards generated.

The combustion bomb is illustrated in Fig. 1, and consists of a body *A* and head assembly *B*, *F*. The body is a cylindrical vessel of stainless steel ('Staybright FMB' supplied by Messrs. Firth Vickers) turned from the solid (internal diameter 0·937 in., external diameter 1·625 in. and internal length 7·125 in.).



Brazed to the body is a valve, consisting of a stainless steel ball *a*, and a seat, machined in the side of *A*. The ball is moved by the threaded brass sleeve and knob *b*. One end of *b* bears against the cup *d*, and the other against the washer *e*. A self-locking nut *f* is screwed on to the end of the non-rotating shaft *c*. The sleeve and shaft are enclosed by the metal bellows *g*, which forms a gas seal.

The valve outlet is threaded to receive a standard hand-tightened vacuum connector, and is covered by the cap *k*, when the bomb is heated in steam.

The head consists of a block *B*, into which is screwed a diesel engine heater plug *C* (*KLG* type 737). The plug filament, *D*, is mounted on two monel metal rods, *E*, 4·5 in. in length. The block *B* is brazed to the end of the heater plug at *X*, and the inner face of the unit is chromium plated. *B* is clamped to *A* by the screwed collar *F*, and the silicone-rubber ring *G* forms a gas seal. *B* is replaced by a stainless steel disk, *H*, during evacuation and gas generation.

The sample, the size of which is adjusted to yield about 300 µl. of water, is attached to the filament as described below. The body *A* is dried immediately before use in an oven at 105° C., and while it is still hot, *B* is placed in position and secured by the collar *F*. Oxygen is then introduced to a pressure of 250 lb. per sq. in. The bomb is inverted and current passed through the filament to ignite the sample. The lower part of the bomb is cooled for 5 min. in a 'dry-ice' – propanol mixture, after which the pressure is released. The head is removed, a glass tube containing 3 gm. of aluminium carbide is introduced, and the body is sealed with the disk *H*. The pressure in the bomb is reduced to less than $1{\cdot}5 \times 10^{-2}$ mm. mercury, the valve is closed, and the outlet covered by the cap *k*. The gas for counting is now generated by heating the bomb for 30 min. in a domestic pressure cooker at 20 lb. per sq. in. Finally,

Sample	Result
1. Active water standard	122 ± 0·34* counts/sec.
" " " × 1/2	62·7 ± 0·13 " "
" " " × 1/6	21·5 ± 0·16 " "
" " " × 1/12	11·0 ± 0·11 " "
" " " × 1/24	6·04 ± 0·087 " "
	1·00 ± 0·009 " "
2. Water from filter paper combustion 313 μl. + standard 20 μl.	14·1 counts/sec. (calc. 14·1)
3. Filter paper 492 mgm.: 496 mgm.	*f*† = 0·566 : 0·567
Cigarette papers (10) 480 mgm.: 483 mgm.	*f* = 0·534 : 0·535
4. Tritium labelled DL-leucine from paper chromatogram (64 μgm.)	148 ± 1·3 μc./gm.
5. Rat serum protein fractions: albumin	7·24 ± 0·038 counts/sec.
a globulin fraction	2·65 ± 0·10 " "
blank (519 mgm. paper)	1·02 " "
6. Rat skeletal muscle: 462 mgm.	126 counts/sec. *f* = 0·619
381 mgm.	128 " " *f* = 0·605

* Errors shown are standard errors calculated from three determinations.
† *f* = isotope dilution, or water equivalent of the material.

the bomb is cooled in tap water, and the gas transferred to the counter tube[1].

Attention has been given to the assay of substances separated on filter paper by chromatography and electrophoresis, since these methods are very useful in work with small samples, such as are obtained from experimental animals.

The paper carrying the sample is folded, and wrapped around the filament *D*, and held in position by a loop of tungsten wire. Samples in powder form (for example, dried tissue) are enclosed in cigarette paper, and similarly attached to *D*. Materials ignited in this way yield clear water after combustion, with no visible traces of carbon. Similar samples held in a crucible, on the filament, were found to be incompletely oxidized.

The results of the first series of tests shown in the accompanying table are the activities of gas, generated in the manner described, from 300-μl. amounts of dilutions of standard active water. It was found that the same isotope dilution occurred when the standard was diluted with water produced by combustion of filter paper (Exp. 2). Samples of the types of paper used in assays were burned, together with added amounts (40 μl.) of standard, in order to determine their isotope dilution (*f* in Exp. 3). Whatman No. 3 *MM* filter paper was dried to constant weight in a current of hot air before combustion.

The tritium-labelled DL-leucine, used in Exp. 4, was prepared by reduction of ethyl 2-acetamido-2-carbethoxy-4-methyl-pentanoate, by adaptation of the method of Albertson and Archer[2]. It is hoped to publish details of this preparation later.

A rat (230 gm.) was given 47 mgm. (7 μc.) of the DL-leucine (dissolved in 1·2 ml. water by addition of the minimum amount of sodium carbonate) by intraperitoneal injection. The animal was killed after 16 hr., a sample of blood collected, and portions of skeletal muscle were dried in a vacuum desiccator. Serum protein fractions (Exp. 5) were obtained by electrophoresis of 97-μl. samples on Whatman 3 *MM* paper. Naphthalene black was used for locating the fractions. Results are given in the table of assays of the albumin, and the most prominent of the globulin fractions, and also a 'blank' sample of the paper immediately in front of the albumin. The skeletal muscle had a lower specific activity than the substances described above, and it was necessary to combust larger amounts. The dried tissue was enclosed in cigarette paper, as previously described. The observed count-rates of the muscle must be corrected to allow for the isotope dilution due to the small amount of paper present. If the correction is made on a weight-for-weight basis, a small error is involved (1·8 per cent and 2·3 per cent in this case), due to the unknown isotope dilution of the muscle. Accordingly, 74 mgm. of muscle was combusted with 409 mgm. of filter paper of known isotope dilution (Whatman 3 *MM*), and a count-rate of 20·9 counts/sec. was observed. This result, in conjunction with the observed count-rates of the 462-mgm. and 381-mgm. samples, respectively, led to the estimates of isotope dilution and activities given in the table.

The simplicity of this method, together with the satisfactory results from the range of materials assayed, indicates that it will be very suitable for routine use.

We would like to thank Prof. B. S. Platt for his interest in this work, and Mr. C. Brown for constructing the apparatus and for valuable suggestions as to its design. [April 12.

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NARCOTICS AND BRAIN RESPIRATION

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It is now well known that narcotics at low concentrations exercise much larger inhibitory effects on the respiration of stimulated nerve than on that of the unstimulated preparation. Bronk and Brink[1] have shown that the rate of oxygen uptake of resting frog nerve is reduced 15 per cent by 2 m*M* chloretone, but that the increment in the rate of oxygen uptake by nerves carrying impulses at the rate of 50 impulses/sec. is decreased 50 per cent by the same quantity of narcotic. McIlwain[2] has demonstrated that narcotics, such as the barbiturates and chloral, inhibit the respiration of electrically stimulated slices of cerebral cortex at concentrations that have but little perceptible effect on the respiration of the unstimulated tissue. He has also shown[3] that stimulation of the respiration of cerebral cortex by potassium ions and by 2 : 4-dinitrophenol renders the respiration more sensitive to the action of barbiturates and chloral. Buchel[3] has pointed out that removal of calcium ions has effects on brain cortex respiration and narcotic sensitivity similar to those due to excess potassium ions.

It is the purpose of this article to describe further results bearing on the sensitivity of brain cortex *in vitro* to narcotics, under conditions where brain metabolism has been affected by the presence of potassium ions and 2 : 4-dinitrophenol. The narcotics examined include luminal (phenylethyl barbiturate), pentothal, chloretone and ethanol.

Experimental procedure. The experimental work was carried out using the conventional Warburg manometric apparatus. Rat brain cortex was largely used in the experiments to be described; but guinea

* On study leave from the Indian Council of Medical Research.

Table 1. Effects of Potassium Chloride and 2 : 4-Dinitrophenol on the Sensitivity of Rat Brain Cortex Respiration to Luminal and Chloretone

Narcotic used	Without KCl		With KCl (0·1 *M*)		Without DNP		With DNP ($2·5 \times 10^{-4}$ *M*)	
	Qo_2	Per cent inhibition	Qo_2	Per cent inhibition	Qo_2	Per cent inhibition	Qo_2	Per cent inhibition
Luminal								
0	12·4		23·5		13·8		25·0	
1·7 m*M*	10·0	19·3	14·8	37·0	11·2	18·9	15·2	39·2
3·3 m*M*	7·5	39·5	10·5	55·3	8·8	36·3	10·0	60·0
Pentothal								
0	12·0		17·2		11·8		19·2	
0·1 m*M*	13·5	Nil	13·2	23·2	12·2	nil	13·8	28·1
1·0 m*M*	10·9	9·1	10·9	36·6				
Chloretone								
0	12·6		21·3		12·2		23·4	
1·4 m*M*	10·5	16·7	13·2	38·0	10·6	13·1	14 5	38·0
2·8 m*M*	8·5	32·6	9·7	54·5	8·8	27·8	10·5	55·1

Vessel contents: slices of rat brain cortex (approximately 90 mgm. fresh tissue) in 3 ml. Ringer–phosphate–glucose (0·01 *M*) medium, containing additions shown in table. The respiratory activities cited are those obtained thirty minutes after addition of the narcotic

pig cortex has also been used with similar results. The animals (body weight 150–250 gm.) were killed by decapitation, the brains removed and cortex sections cut with a Stadie–Riggs slicer. The slices were weighed wet immediately and dry weight calculated by a factor determined by drying a known quantity of wet tissue to constant weight at 110°. The slices (average 90 mgm. wet weight) were allowed to respire at 37° in oxygen in a medium of the following composition: NaCl, 128 m*M*; KCl, 5 m*M*; $CaCl_2$, 0·6 m*M*; $MgSO_4$, 1·3 m*M*; KH_2PO_4, 1·3 m*M*; Na_2HPO_4, 10 m*M*, brought to *p*H 7·4 with *N* HCl. The medium contained glucose (0·01 *M*) except when otherwise stated.

Carbon dioxide liberated during respiration was absorbed by potassium hydroxide in the centre wells of the manometric vessels.

A solution of the narcotic or of potassium chloride (or 2 : 4-dinitrophenol) or of a mixture of both was usually placed in the side tube of the manometer vessel, and was tipped into the medium containing the brain cortex slices when the respiration of the latter had obtained a constant rate, usually about thirty minutes after the commencement of the experiment. Readings of the rate of oxygen consumption were then taken every ten minutes for one hour.

Effects of luminal, pentothal and chloretone on rat brain cortex respiration in presence of added potassium ions. The considerable increase in respiratory activity of brain cortex due to the addition of 0·1 *M* potassium chloride[4] is seen in typical results given in Table 1. The presence of luminal brings about an enhanced inhibition of the rate of respiration in presence of 0·1 *M* potassium chloride, the increase of inhibition above that obtained in absence of potassium chloride amounting to more than 90 per cent at a concentration of 0·0017 *M*. A similar phenomenon is observed when chloretone is used as the narcotic. These results are in accord with those reported by McIlwain[2]. Although the percentage inhibition of the rate of respiration, in absence of the added potassium ions, is directly proportional to the amount of narcotic present, this is not the case in the presence of 0·1 *M* potassium chloride. Here, the increase of inhibition of respiration falls off as the amount of narcotic is increased. Similar conclusions apply to chloretone when this is used at low concentrations (Table 1).

As an example of a barbiturate that has been claimed[5] to exert its effects by uncoupling of phosphorylation and not by oxidative inhibition, pentothal may be cited. This narcotic, which has little or no inhibitive effect at low concentrations on the respiration of brain cortex *in vitro* and may even show a stimulation, is a potent inhibitor, at the same concentrations, when the brain cortex is stimulated by potassium ions. Typical results may be seen in Table 1. The inhibitive effect of this narcotic increases with its concentration, and it has not been observed to give a stimulation with brain cortex in presence of 0·1 *M* potassium chloride, such as may occur with brain cortex in absence of added potassium ions. Conceivably, the stimulation shown by low concentrations of pentothal with brain cortex in the absence of added potassium ions is due to an oxidation of, or a catalysis by, the thiol group of this narcotic.

While these results make it apparent that brain cortex respiration is made much more sensitive to the inhibitive action of narcotics by the presence of 0·1 *M* potassium chloride, another conclusion, not hitherto commented upon, may be drawn from them. The data of a number of representative experiments given in Table 2 make it clear that the presence of the narcotic greatly diminishes the stimulating action of added potassium ions. Thus, whereas the average increase of the respiratory rate of rat brain cortex in a glucose–phosphate medium due to the addition of 0·1 *M* potassium chloride amounts to 70 per cent during the first half-hour after addition of the salt, the increase only amounts to 12 per cent when 0·0033 *M* luminal is present. In no case has it yet been observed that the addition of luminal (or pentothal or chloretone) reduces the rate of respiration of rat brain cortex in presence of 0·1 *M* potassium chloride below that found in the absence of added 0·1 *M* potassium chloride. If the effect of added potassium ions is simply to render the brain cortex more sensitive to the action of the narcotics, it would be expected that respiratory rates *lower* than those found in the absence of added potassium would be found. We have not yet found this to occur. The results, in fact, indicate that the inhibitive action of the narcotic at low concentrations is *restricted* to that

Table 2. Effects of Luminal on Rat Brain Cortex Respiration in Presence of Potassium Cloride

Additions	Qo_2 Without added KCl			Qo_2 With added KCl 0·1 *M*			Average per cent increase of Qo_2 due to KCl
Glucose	14·5	12·6	11·5	24·5	20·0	21·0	70
Glucose + luminal 3·3 m*M*	9·5	7·4	6·9	10·5	8·5	7·8	12

Table 3. Effect of Chloretone on the KCl-stimulated Respiration of Rat Brain Cortex Slices in Presence of Different Substrates (0·01 *M*)

Substrates	Q_{O_2}		Per cent diminution in Q_{O_2}
	No chloretone present	In presence of 3·3 m*M* chloretone	
Glucose			
Without KCl	12·5	8·3	33·5
With KCl	20·5	9·2	55·1
Fructose			
Without KCl	12·6	8·5	32·5
With KCl	20·0	9·5	52·5
Sodium pyruvate			
Without KCl	13·2	10·0	24·2
With KCl	18·8	11·2	40·4
Sodium lactate			
Without KCl	11·8	9·5	20·0
With KCl	16·8	10·2	40·0
Sodium L-glutamate			
Without KCl	7·5	5·0	33·3
With KCl	7·0	5·0	28·5
Sodium succinate			
Without KCl	10·8	10·5	3·0
With KCl	9·0	8·5	5·5

Vessel contents: conditions as in Table 1 except that glucose is replaced by other substrates. Respiratory activities recorded are the average over the first 30 min.

aspect of brain cortex metabolism which is stimulated by potassium ions. Another way of expressing the same result is to state that the stimulating action of potassium ions mainly operates on that aspect of brain cortex metabolism which is inhibited by narcotics at low concentrations.

The stimulating effect of the presence of 0·1 *M* potassium chloride on brain cortex respiration is seen not only with glucose as combustible substrate but also with fructose, sodium pyruvate and sodium lactate[4]. With all these substrates, the increased effect of the narcotic in diminishing the respiration stimulated by potassium chloride is observable. Typical results with chloretone (0·0033 *M*) are shown in Table 3. It will also be observed that there is but little stimulating effect of the added potassium ions on the respiration of brain cortex in presence of fructose, lactate or pyruvate when the narcotic is also present.

When sodium L-glutamate is present as substrate in place of glucose, no stimulating effect of added potassium on the respiration is found[6] nor is the narcotic effect increased (Table 3). Moreover, when sodium succinate is present as substrate, neither stimulation of the rate of respiration by added potassium ions nor increased sensitivity of the respiration to the narcotic, within the experimental error of these observations, is observable (Table 3).

A fact supporting the conclusion that both the inhibitive activity of narcotics and the stimulating effect of potassium ions are directed to the same aspect of brain respiration is the observation that homogenized brain tissue in presence of glucose has a respiration which is neither stimulated by 0·1 *M* potassium chloride nor inhibited by low concentrations of narcotics.

A possible explanation of these results is that the presence of high concentrations of potassium ions catalyses the processes of formation of energy-rich phosphates, such as adenosine triphosphate[7], which in turn enhance the rates of oxidation of glucose or pyruvate[8]. Granting these facts, and the correctness of the conclusion that narcotics at low concentrations block oxidative synthesis in the brain of adenosine triphosphate[9] and pyruvate oxidation[10], it is apparent that, in the presence of narcotics, the stimulating effect of potassium ions will be reduced or eliminated. It follows, too, if this view is correct, from the results given in Tables 2 and 3 that a considerable fraction of the respiration of brain cortex is neither narcotic-sensitive (for low concentrations of narcotics) nor responsive to the presence of high concentrations of potassium ions.

It is of considerable interest in this connexion to recall the observations of Lipsett and Crescitelli[6], who have shown that the potassium stimulation of oxygen uptake by rat brain is inhibited by the addition of 0·01 *M* citrate, α-ketoglutarate, L-glutamate or succinate. The suggestion made by the authors is that these substances (the oxidation of which is not stimulated by 0·1 *M* of potassium chloride) yield large amounts of high-energy phosphate during their metabolic breakdown. It is, however, also possible that these substances, by competition with glucose or pyruvate for common carriers in brain respiration, may have sparing effects on the utilization of glucose or pyruvate and thus diminish the potassium stimulation. This is obviously a matter for further investigation. Reference should also be made to the work of Kimura and Niwa[11], who have shown that the potassium stimulation of brain cortex respiration is inhibited by malonate, which has relatively little effect on the unstimulated respiration. This would indicate that the narcotic-sensitive respiration is also highly malonate-sensitive, a fact which is consistent with the conclusion that the stimulated phase involves the oxidation of carbohydrate (or pyruvate) through the operation of the citric acid cycle.

Effects of luminal, pentothal and chloretone on rat brain cortex respiration in presence of 2 : 4-*dinitrophenol.* The increased respiration of rat brain cortex in presence of 2 : 4-dinitrophenol ($2·5 \times 10^{-5}$ *M*) is, like that due to excess potassium ions, highly sensitive to the inhibitory action of narcotics. Typical results are shown in Table 1 and are in agreement with the results of McIlwain[3] obtained with guinea pig brain. Again, it is clear that in the presence of small concentrations of narcotics the stimulatory effect of 2 : 4-dinitrophenol is greatly reduced. A comparison of the effects of potassium ions and of 2 : 4-dinitrophenol on rat brain cortex respiration is given in Table 4.

An explanation similar to that given for the results with 0·1 *M* potassium chloride may apply to those obtained with dinitrophenol. Recent evidence[11] makes it likely that the accelerative effects of 2 : 4-dinitrophenol are due to an increase in the rate of breakdown of adenosine triphosphate to adenosine diphosphate, which by acting as phosphate acceptor serves to stimulate oxygen uptake. Here again, if the narcotic blocks oxidative synthesis of adenosine

Table 4. Effects of Potassium Ions and of 2 : 4-Dinitrophenol on Respiration of Rat Brain Cortex in Presence of Narcotics

System	Per cent increase of respiration due to KCl (0·1 *M*)	Per cent increase of respiration due to DNP ($2·5 \times 10^{-5}$ *M*)
Glucose only	55	55
Glucose + luminal 1·7 m*M*	10	15
Glucose + luminal 3·3 m*M*	5	8
Glucose + chloretone 1·4 m*M*	10	12 to 15
Glucose + chloretone 2·8 m*M*	4	10
Glucose + ethyl alcohol 0·02 *M*	15	10
Glucose + ethyl alcohol 0·2 *M*	10	8
Glucose + ethyl alcohol 0·4 *M*	7	Nil

The values given in this table refer to respiratory activities calculated during the 30–60 min. interval of the experiment

Table 5. Effects of Ethyl Alcohol on the Normal and KCl-stimulated Respiration of Rat Brain Cortex Slices

System	Average Qo_2		
	30m.	60m.	90m.
Glucose (0·01 *M*) only	12·5	12·2	12·0
Glucose (0·01 *M*) + ethanol (0·02 *M*)	14·4	14·0	13·8
Glucose (0·01 *M*) + ethanol (0·2 *M*)	13·8	13·5	13·0
Glucose (0·01 *M*) + ethanol (0·4 *M*)	13·8	13·0	12·0
Glucose (0·01 *M*) + KCl (0·1 *M*)	21·4	20·3	18·0
Glucose (0·01 *M*) + KCl (0·1 *M*) + ethanol (0·02 *M*)	19·2	17·0	14·6
Glucose (0·01 *M*) + KCl (0·1 *M*) + ethanol (0·2 *M*)	18·0	15·0	13·0
Glucose (0·01 *M*) + KCl (0·1 *M*) + ethanol (0·4 *M*)	16·4	14·0	11·8

Table 6. Effects of Ethyl Alcohol on the Normal and 2 : 4-Dinitrophenol-stimulated Respiration of Rat Brain Cortex Slices

System	Average Qo_2		
	20m.	40m.	60m.
Glucose (0·01 *M*) only	12·6	12·0	12·0
Glucose (0·01 *M*) + ethanol (0·02 *M*)	15·0	14·8	14·0
Glucose (0·01 *M*) + ethanol (0·2 *M*)	15·0	14·5	13·8
Glucose (0·01 *M*) + ethanol (0·4 *M*)	14·7	14·0	12·0
Glucose (0·01 *M*) + DNP ($2·5 \times 10^{-5}$ *M*)	24·0	22·8	20·8
Glucose (0·01 *M*) + DNP ($2·5 \times 10^{-5}$ *M*) + ethanol (0·02 *M*)	22·0	17·0	15·0
Glucose (0·01 *M*) + DNP ($2·5 \times 10^{-5}$ *M*) + ethanol (0·2 *M*)	20	16	13·2
Glucose (0·01 *M*) + DNP ($2·5 \times 10^{-5}$ *M*) + ethanol (0·4 *M*)	17·4	13·8	10·0

triphosphate, the stimulatory action of 2 : 4-dinitrophenol will be reduced or eliminated.

Ethanol as a narcotic. It is known[13–15] that brain tissue is capable of oxidizing ethanol when this is present in small concentrations, and possibly this fact has made it difficult to study narcotic effects of ethanol *in vitro*. Depression of brain metabolism *in vivo* by ethanol has been observed[16,17].

Results given in Table 5 and Table 6 show that the addition of ethanol at small concentrations to rat brain cortex slices respiring in a glucose–phosphate medium brings about an increase in the rate of respiration, the increase being diminished with increase of ethanol concentration (see also Buchel[3]).

Ethanol, however, even at the lowest concentration tested (0·02 $M \equiv 92$ mgm. per cent) exercises a definite inhibition of rat brain cortex respiration in presence of 0·1 *M* potassium chloride. As will be seen from the results given in Table 5, the presence of ethanol brings about inhibitions of the stimulated respiration of rat brain cortex that increase with increase of ethanol concentration. The same phenomenon holds with 2 : 4-dinitrophenol-stimulated respiration of rat brain cortex (Table 6). These observations indicate that ethanol behaves in a manner similar to luminal or pentothal or chloretone on the stimulated respiration of rat brain.

It is likely, though not yet proved, that the increase of respiration of unstimulated rat brain due to the addition of small concentrations of ethanol is due to oxidation of the ethanol itself, and that such increase is obscured by the stimulation of oxidation that occurs in a glucose medium in presence of 0·1 *M* potassium chloride or of 2 : 4-dinitrophenol.

In the light of these results it would appear that narcotics, at pharmacologically active concentrations, exercise large inhibitive effects on the total respiration of the stimulated nerve cell by suppressing that aspect of respiration capable of response to the presence of high concentrations of potassium and which is concerned with carbohydrate (or pyruvate) oxidation. With the resting, unstimulated, nerve cell the respiration is due to processes a considerable proportion of which are neither highly sensitive to narcotic nor capable of stimulation by potassium ions. It is for this reason that apparently so little effect on the respiration of the unstimulated nerve *in vitro* is seen by a narcotic at pharmacologically active concentrations. With stimulated nerve, however, the potassium-responsive, narcotic-sensitive, aspect of respiration becomes the more prominent phase.

The general conclusion that narcotics, at pharmacologically active concentrations, act on the nerve cell, where they are adsorbed, by the suppression of oxidative events, particularly those involved in glucose or pyruvate oxidation, is thus supported.

Summary

The increased respiration of rat brain cortex *in vitro*, brought about by addition of potassium ions or of 2 : 4-dinitrophenol, is suppressed or eliminated by the presence of pharmacologically active concentrations of barbiturates, such as luminal or pentothal, or of chloretone. The increased sensitivity of the respiration of stimulated brain cortex to narcotics is due to a retarding effect of the narcotics on a specific phase of nerve respiration that is potassium-sensitive and concerned with glucose (or pyruvate) oxidation. This phase is not prominent in a resting, unstimulated, nerve, the respiration of which is made up largely of processes that are unresponsive to potassium or insensitive to low concentrations of narcotics. This phase, however, becomes an important aspect of the respiration of stimulated nerve. The presence of ethanol at low concentrations (0·1 per cent) brings about a decided inhibition (20 per cent) of the respiration of rat brain cortex stimulated by potassium or by 2 : 4-dinitrophenol. The same concentration of ethanol increases the respiration of unstimulated brain cortex probably by undergoing an oxidation, which is obscured by the stimulation of respiration in a glucose medium by the addition of potassium ions or of 2 : 4-dinitrophenol.

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LETTERS TO THE EDITORS

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Fractionation of Deoxyribonucleoprotein by Successive Extraction with Constant Salt Concentration

In recent papers Chargaff and his collaborators[1], and Brown and Watson[2], have shown the possibility of obtaining nucleic acids (DNA) of varying composition from deoxyribonucleoprotein. Chargaff's fractionation was achieved by successive extractions of nucleoprotein with salt solutions of increasing strength, after the nucleoprotein had been precipitated by a mixture of chloroform and *n*-octanol. This yielded a series of nucleic acid fractions containing progressively increasing quantities of adenine and thymine. Chargaff has suggested that this fractionation may arise from the existence of bonds of varying stability, between the protein and the nucleic acid, which are broken progressively with increasing salt concentration. It may be noted that in the observations quoted, although fractions of differing composition were undoubtedly obtained, there were marked irregularities in the way in which the composition of the fractions varied with the salt concentration used in extraction. This suggested to us that some other variable may have had a significant effect on the results obtained.

Attempts were made to fractionate nucleoprotein directly, without prior chloroform treatment; and by slowly adding or removing salt by dialysis, to obtain fractional solution and precipitation respectively of the nucleoprotein. Though the nucleoprotein was fractionated into soluble and insoluble material at salt concentrations of both 0·65 *M* and 0·75 *M* by this means, the nucleic acids thus obtained showed no significant differences in composition.

We then investigated the result of extracting the chloroform-denatured nucleoprotein successively with the same salt solution. Fresh, minced calf thymus glands were washed five times with 0·9 per cent sodium chloride, homogenized in water, and then mixed with an equal volume of chloroform (35 parts) and amyl alcohol (10 parts) for five minutes in a Waring blendor. The gel obtained on centrifugation at 20,000 *g* was blended into excess 0·6 *M* sodium chloride for one minute, and the extract stirred slowly overnight. After centrifugation at 32,000 *g* for three hours, the viscous supernatant liquid was decanted, precipitated with alcohol, and protein removed from the material to yield the nucleic acid. The residue, partly compact and partly gel-like, was then extracted further with 0·6 *M* salt solution as above. All operations, except deproteinization, were performed at temperatures below 5° C. In experiment I, protein was removed by treatment with chloroform and amyl alcohol in 10 per cent salt solution[3], whereas in experiment II protein was removed by a detergent method[4]. A small dilution of the sodium chloride by the water present in the gel occurs in the first extraction; but in subsequent extractions this is negligible.

We are able to extract successive nucleoprotein fractions by the above procedure, and the deoxyribonucleic acids obtained in these extractions have been found to vary progressively in composition, as can be seen from the results of the two experiments given in Table 1. In experiment II, more than 50 per cent of the total salt-soluble phosphorus was extracted in five successive extractions.

Each value of (adenine + thymine)/(guanine + cytosine) is the mean of three determinations on one perchloric acid hydrolysate of the substance[5]. No individual value differed from the mean of the three by more than 3 per cent (except fraction II 1), and the average difference from the mean value was less than 2 per cent. Fractions I 2 and II 2 were hydrolysed in duplicate and the mean values differed by only 1 per cent in each pair of hydrolysates.

In the first two extracts of both I and II, the nucleoprotein as precipitated by alcohol was largely non-fibrous, and precipitation required several hours at about 4° C., whereas the later extracts immediately gave the usual fibrous precipitate. The specific viscosities of the isolated nucleic acid fractions did not vary greatly, though all were lower than that of thymus deoxyribonucleic acid ($\eta_{sp}(P) = 1{,}045$), in which protein had been removed with chloroform/amyl alcohol in 10 per cent salt solution.

There is no doubt that the chloroform-treated nucleoprotein is in a different state from the native material. Extracts of the denatured material in 0·6 *M* salt solution after precipitation with alcohol yield nucleoprotein soluble in 10 per cent salt solution, whereas material extracted similarly from the native nucleoprotein and precipitated with alcohol is insoluble in 10 per cent salt solution[4].

Table 1. Composition of Calf Thymus Deoxyribonucleic Acid Fractions

Experiments	Fraction	Sodium chloride molarity	% of total[b] soluble phosphorus	N/P[b]	$\eta_{sp}(P)$[c]	Adenine / Thymine	Guanine / Cytosine	A + T / G + C
I	1	0·6				1·08	1·14	0·88
	2					1·24	1·17	0·88
	3					1·05	1·10	1·16
	4					1·07	1·12	1·21
II	1	0·6	2·5	25·0	—	0·99	1·13	0·76[d]
	2		4·6	5·4	727	1·09	1·18	0·85
	3		12·9	4·2	820	1·07	1·14	1·05
	4		18·0	3·8	984	1·06	1·11	1·20
	5		18·5	3·8	898	1·04	1·08	1·30
	Residue[a]		43·5	3·5	955	1·03	1·13	1·31
Unfractionated deoxyribonucleic acid (chloroform deproteinization, ref. 3)						1·07	1·06	1·20
Unfractionated deoxyribonucleic acid (detergent deproteinization, ref. 4)						1·01	1·18	1·22

a, The residue in II was extracted in 10 per cent sodium chloride solution.
b, Total phosphorus and nitrogen was determined in each salt extract.
c, $\eta_{sp}(P)$ is the specific viscosity (Ostwald type viscometer) of the deoxyribonucleic acid divided by the molarity of the solution with respect to phosphorus. Solutions were 0·1 per cent deoxyribonucleic acid in 0·1 *M* sodium chloride. Outflow time for 0·1 *M* sodium chloride was 13·2 sec. at 25° C.
d, Fraction II 1 accurate to within 5 per cent.

It can be concluded that whatever is the actual process that gives rise to the fractionation, the essential variable is not the concentration of sodium chloride in the extracting solution. The nitrogen/phosphorus ratios of the extracted nucleoprotein fractions given in Table 1 show that the ratio protein/nucleic acid decreased in the successive extractions. But the excess of protein extracted in the early fractions may have been extraneous, and not closely associated with the deoxyribonucleic acid. However, the fractionation of the deoxyribonucleic acid might possibly be a consequence of the fact that a high protein/deoxyribonucleic acid ratio occurs in those fractions which are richer in guanine and cytosine.

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Effect of Hæm-linked and Other Ionizations on Hæmoprotein Reactions

The ionization of a proton from a 'hæm-linked' acidic group, generally believed to be on the amino-acid residue to which the hæm is attached, is known to alter the affinity of the iron atom for a ligand, as in the combination of the ferrous hæmoprotein, hæmoglobin, with oxygen (Bohr effect)[1]. If a similar effect operates in the formation of ferric hæmoprotein complexes, then it may be very difficult to decide, from the variation with *p*H of equilibrium or of velocity constants, or from determinations of the *p*H changes which accompany complex formation in unbuffered solutions, whether complexes formed with ligands possessing acid-base properties contain the undissociated ligand, H*X*, or its anion, X^-, bonded to the iron atom[2]. However, a knowledge of the acid strengths of hæm-linked groups, obtained from reactions where the effect of *p*H comes entirely from their ionizations, such as the oxygenation and electrode reactions, does enable a definite choice to be made. In this way we have recently shown[2] that the fluoride and cyanide complexes of the ferric hæmoprotein, metmyoglobin, involve bonding of fluoride and cyanide ions.

But in the case of the hæmoprotein enzymes, catalase and peroxidase, the simplest interpretation of the scanty data on the variation of equilibrium and velocity constants with *p*H suggests bonding of the undissociated ligands HF, HCN, HN_3, etc.[3]. Yet the physical properties of the complexes, particularly absorption spectra and magnetic susceptibilities, resemble so closely those of metmyoglobin and methæmoglobin that on these considerations alone anion bonding has long been accepted[4]. One explanation of the apparent contradiction could be that anions are bonded in all the complexes, but in metmyoglobin reactions the ionization of a hæm-linked group only slightly modifies the *p*H variation of equilibrium and velocity constants indicative of anion bonding, whereas the *pK* values of the linked ionizations in catalase and peroxidase are such as to alter it completely.

In addition to the effect of a hæm-linked group, the ionization of other acidic groups on the hæmoprotein would be expected to influence the reactivity of the iron atom by altering the 'ionic strength charge' (*Z*)[5]. Such an effect should be most readily detectable at very low ionic strengths (*I*), where the magnitude of the charge could be obtained from the variation of an equilibrium or velocity constant with $\sqrt{I}$. The effect would probably be a composite one since every charged group would exert an influence depending, among other factors, upon its distance from the iron atom and upon the dielectric constant of the medium between (which might be low like that of the backbone chain of a polypeptide, or high like that of polar side-chains or solvent water molecules). On the same basis, the charge on a hæm-linked group should also contribute to the value of *Z*.

We have obtained values for the changes in *Z* for three metmyoglobin reactions[6,7]. In the table these values are given to the nearest whole number, together with the corresponding changes in the 'formal charge' on the iron atom, which is usually taken as + 1 in metmyoglobin on the grounds that two of the three positive charges are neutralized by negative charges on pyrrollic nitrogen atoms of the porphyrin ring. The table shows that at *p*H values between 6·6 and 7·5, where the hæm-linked group[2] is predominantly ionized in metmyoglobin ($pK \sim 6{\cdot}0$) and in its fluoride complex ($pK \sim 6{\cdot}4$), the change in both quantities is from + 1 to zero as the complex forms. Determinations of the *pK* of the linked group on the fluoride complex, from the slight increase in the intensities of its absorption bands over the *p*H range 5·8–6·7, also indicate that *Z* changes from + 1 to zero in this reaction[7]. Although this ionization does not involve any change in the formal charge on the iron atom, provided the hæmatin group and its linked acidic group are considered as one unit, this result is consistent with the previous one, and can be readily accounted for by the ionization of a cationic acid, for example, the glyoxalinium NH^+ of histidine.

Changes in Charge accompanying Metmyoglobin Reactions. $Fe^+(H_2O)$ represents the ferric iron atom in metmyoglobin with its co-ordinated water molecule. H^+Y and *Y* represent, respectively, the conjugate acidic and basic forms of a hæm-linked group with the charge assigned arbitrarily

Metmyoglobin reaction	Formal charge on Fe	Ionic strength charge (*Z*) (nearest whole number)
$Y.Fe^+(H_2O) + F^- \rightleftharpoons Y.FeF + H_2O$ at *p*H values between 6·6 and 7·5 (ref. 7)	+ 1 → 0	+ 1 → 0 in range of $I = 0{\cdot}01$–$0{\cdot}10$
$H^+Y.FeF \rightleftharpoons Y.FeF + H^+$ from *p*H 5·8 to 6·7 (ref. 7)	0 → 0	+ 1 → 0 in range of $I = 0{\cdot}025$–$0{\cdot}10$
$Y.Fe^+(H_2O) \rightleftharpoons Y.FeOH + H^+$ from *p*H 8·5 to 9·4 (ref. 6)	+ 1 → 0	− 2 → − 3 in range of $I = 0{\cdot}002$–$0{\cdot}010$

But a more complicated co-operative effect cannot be excluded. For example, the ionization may be that of a carboxylic acid where the influence of the negative charge of the carboxylate ion is compensated for by the positive charge of a cationic acid. In this connexion the ionization of the two propionate side-chains of the ferriprotoporphyrin merit consideration, particularly in view of J. Keilin's observations on copper uroporphyrin[8], where a $pK \sim 5{\cdot}7$ was obtained from the change in absorption spectrum with pH, a probable consequence of the ionization of the acetate and propionate side-chains. Preliminary estimates[7] of the heat and entropy of ionization of the hæm-linked group in metmyoglobin, obtained from the variation of pK with temperature at $I = 0{\cdot}10$, give $\Delta H^0 = 2 \pm 2$ kcal.mole^{-1} and ΔS^0 about -20 e.u., which more closely resemble the thermodynamic constants for the ionization of a carboxylic acid than those for the NH^+ of histidine.

Whereas in the pH range 6·6–7·5, which spans the isoelectric point, it is not apparently necessary to invoke a charge contribution from acidic groups other than the hæm-linked group, this is no longer so in the pH range 8·5–9·4, where the ionization occurs of the water molecule co-ordinated to the iron. Here the change in formal charge is again + 1 to 0, but the corresponding values of Z are -2 and -3 (see table). This suggests that between pH 7·5 and 8·5 the equivalent of three negative charges has been produced, and as carboxyl groups are unlikely to become ionized in this range, the effect is probably due to the ionization of cationic acids the positive charges of which otherwise compensate for the effect of the negatively charged carboxylate ions. Depending on the extent to which the two propionate side-chains of the ferriprotoporphyrin contribute to this charge, the equivalent of between one and three acidic amino-acid residues (aspartic or glutamic[9]) will also be needed. The cationic acids may include glyoxalinium NH^+ groups of histidine, or the α-NH_3^+ of the terminal glycine in metmyoglobin[10].

It is significant that although these three negative charges contribute to the value of Z, and as a consequence influence the reactivity of the hæmatin iron atom, the ionization of the groups concerned does not apparently alter the affinity of the iron for fluoride at high ionic strengths[7]. In this respect, the ionizations can be differentiated from the hæm-linked ionizations with which the Bohr effect is associated, and the contrast in behaviour substantiates the idea that some special structural or configurational feature must be present before an ionization can have the properties which characterize a hæm-linked ionization.

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Biosynthesis of Hæmin in Soy-bean Nodule Homogenates

It has been shown that root nodules of leguminous plants contain a hæmoprotein with a prosthetic group indistinguishable from protohæmin IX of hæmoglobin[1]. Elucidation of the mechanism of formation of this pigment in plant material should broaden our knowledge of biosynthetic reactions leading to the formation of porphyrins, and make it possible to compare hæmin synthesis in plant and animal tissues.

The work to be reported was carried out with soy-bean root nodules harvested from plants approximately six weeks of age. 5-gm. portions of nodules were homogenized with a Waring blendor in 30 ml. of 0·2 molar phosphate buffer, pH 7·1. The ability of these preparations to incorporate the carbon atoms of glycine and acetate into hæmin was investigated by incubating the homogenates for three and a half hours in modified Warburg vessels at temperatures ranging from 18° to 37° C. in the presence of various substrates. Hæmin was isolated and purified by chromatography on a 'Celite' column, and identified spectroscopically as the pyridine hæmochromogen of protohæmin IX. In a few cases the pyridine hæmochromogen was converted to its corresponding porphyrin ester according to Grinstein[2] and found to be indistinguishable spectroscopically and by means of column chromatography from that isolated from hæmin IX. Table 1 shows some typical results.

Table 1. Incorporation of the Carbon Atoms of Glycine and Acetate into Hæmin in Soy-bean Root Nodule Homogenates

Test substance	Radioactivity in hæmin*
2-^{14}C-Glycine	38 × 10^3
1-^{14}C-Glycine	4 × 10^3
2-^{14}C-Acetate	45 × 10^3
1-^{14}C-Acetate	38 × 10^3

* Expressed as disintegrations per mM/min./5 gm. wet weight of nodules/μc. of test substance.

As can be seen from the table, soy-bean root nodule homogenates, like animal tissues[3], are able to incorporate the alpha carbon atom of glycine and the carbon atoms of acetate into hæmin.

Differences between nodule homogenates and animal tissues in their ability to incorporate glycine and acetate into hæmin are presented in Table 2.

The differences between root nodules and bone marrow in their ability to incorporate 1-^{14}C-glycine

Table 2. Differences between Soy-bean Root Nodules and Bone Marrow in their Ability to Incorporate Glycine and Acetate into Hæmin

Variable observed	Soy-bean root nodules	Bone marrow
Incorporation of 1-^{14}C-glycine	Slight incorporation (approx. 10 per cent)*	No detectable incorporation
Incorporation of 1-^{14}C-acetate	About the same incorporation as of 2-^{14}C-acetate	Less incorporation than of 2-^{14}C-acetate (approx. 60 per cent)†
Effect of 0·01 M sodium fluoride on incorporation of the carbon atoms of glycine into hæmin	Stimulatory (approx. 400 per cent for 1-^{14}C-glycine; approx. 190 per cent for 2-^{14}C-glycine)	Inhibitory (approx. 50 per cent for 2-^{14}C-glycine)
Temperature	Optimum, 25° C.	Optimum, 37° C.

* Expressed as per cent incorporation of 2-^{14}C-glycine.
† Expressed as per cent incorporation of 2-^{14}C-acetate.

and in their response to the presence of fluoride warrant further investigations which are now being undertaken in this laboratory.

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Hæmoglobin in *Heterakis gallinae*

A NUMBER of helminths and especially parasitic nematodes are known to possess a hæmoglobin-like pigment[1–3]. In some instances, a detailed study has been made of the pigment after extraction and purification[2,4]. From the discussion in the literature, it is apparent that no general conclusion as to the physiological significance of the hæmoglobin of parasites can be made.

The present investigation adds another nematode, *Heterakis gallinae*, from the cæca of the fowl, to the list of parasites containing hæmoglobin. The following observations were made on adult worms with a reversion spectroscope (Beck–Hartridge): wavelengths in millimicrons.

	Oxyhæmoglobin		Carboxyhæmoglobin		Hæmoglobin	Pyridine hæmochromogen	
	α-band	β-band	α-band	β-band		α-band	β-band
Heterakis	578·3	542	570·0	c. 530	555	557	525
Fowl blood*	578·0	541	571·8	537	556		

* There is a slight difference between our results and those of Anson *et al.*[5]: they give 576·4 as the position of the α-band in man and 576·9 in the fowl. We found, with our spectroscope, in man 577·2 and in the fowl 578·0.

It was noted that the hæmoglobin was rapidly deoxygenated by the respiratory activity of the worm, a fact which is in accordance with the high values of oxygen uptake found by Glocklin and Fairbairn[6].

It appears that there is little difference between the position of the bands of *Heterakis* hæmoglobin and those of the blood of the host.

Nevertheless, the hæmoglobin of *Heterakis* is probably an autochtonous pigment because (1) the absorption bands remained in the same position over a period of 24 hr. in washed parasites which were placed in an incubator at 37° C.; (2) adult *Heterakis* feed on the cæcal content and not on tissues or blood, as is possibly the case in the larval stage since there exists a tissue phase in the developmental cycle[7].

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Biological Value of Proteins as influenced by Dietary Vitamin B_{12}

IT has been shown by Frölich[1] that chicks, fed underheated, low-quality soy bean oil meal, were depleted of their vitamin B_{12} reserves and consequently required the supply of dietary vitamin B_{12}, probably due to the antiproteolytic activity[2] or soyin content[3] of the underheated meal. Baliga and Rajagopalan[4] have reported that vitamin B_{12} at 50 μgm. per kilo of the diet containing 10 per cent raw soy bean protein (without any heat treatment) enhanced the biological value of the protein (the biological values for the raw and vitamin B_{12} supplemented soy bean protein being $48{\cdot}6 \pm 0{\cdot}9$ and $77{\cdot}6 \pm 1{\cdot}8$ respectively). This would suggest that vitamin B_{12} has overcome the adverse effect of the proteolytic inhibitor and soyin. These studies were extended to determine the effect of vitamin B_{12} on the biological value of autoclaved soy bean meal. These observations are presented here.

Cold defatted and autoclaved (at 15 lb. pressure for 30 min.) soy bean meal, at 10 per cent protein-level in the diet, was used for the determination of biological value by the method of Mitchell[5]. There were three comparable groups of albino rats, containing six rats in each group and each rat weighing 80–100 gm. After determining the endogenous nitrogen with 4 per cent egg protein, one group (*A*) was given the basal diet[4] containing the autoclaved soy bean meal, the second group (*B*) was given the same basal diet with vitamin B_{12} at 50 μgm. per kilo of the diet and the third group (*C*) received the basal diet with aureomycin at 200 mgm. per kilo of the diet. The figures for the biological values for the *A*, *B* and *C* groups were $78{\cdot}30 \pm 0{\cdot}3$, $85{\cdot}40 \pm 1{\cdot}0$ and $86{\cdot}43 \pm 1{\cdot}40$ respectively. These data clearly show that vitamin B_{12} has a definite function in increasing the utilization of soy bean protein irrespective of the extent of heat treatment. This observation is contradictory to that of Frölich (*loc. cit.*) who, using chicks, did not find vitamin B_{12} to have any beneficial influence on growth with adequately heated soy bean meal. Our results also indicate that aureomycin exerts a significant increase in the biological value of autoclaved soy bean meal.

It was of interest to find out whether an animal protein, like casein, would respond to vitamin B_{12} in the presence of proteolytic inhibitor and soyin. Each of three more groups of rats received 10 per cent casein in the basal diet in place of soy bean meal. Three lots of crude and active inhibitor preparation were made[6] from soy bean the quantity of which was the same as that which formed the 10 per cent protein-

level in the original basal diet. One lot of the inhibitor preparation was inactivated by heat and added to the control group of rats. The other two groups received the active inhibitor preparation. To one of these two groups, vitamin B_{12} was added at a level of 50 μgm. per kgm. of the diet. The following biological values were obtained: casein plus inactivated inhibitor, $86{\cdot}6 \pm 1{\cdot}14$, casein plus active inhibitor, $76{\cdot}67 \pm 0{\cdot}82$, casein plus active inhibitor plus vitamin B_{12}, $85{\cdot}19 \pm 0{\cdot}98$.

In the above case, vitamin B_{12} has just counteracted the influence of the inhibitor and has not shown any extra benefit. Whereas with raw soy bean, elimination of the adverse effects of the inhibitors automatically improves the biological value as evidenced by autoclaving the raw soy bean meal, in the case of the casein inhibitor the removal of the inhibitor effect by vitamin B_{12} has resulted in the restoration of the normal biological value. With a higher concentration of vitamin B_{12} in the diet than used in the present studies, it might be possible to get a higher biological value for casein as reported by Kon and Henry[7]. This aspect is being verified.

Studies on the rate of release of certain amino-acids from raw soy bean under the influence of vitamin B_{12}, and nitrogen balance and growth studies with different levels of autoclaved soy protein with and without vitamin B_{12} and aureomycin, are in progress.

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Enzymatic Conversion of Salicylhydroxamic Acid to Salicylamide

After the administration of salicylhydroxamic acid to rats, we have been able to isolate conjugates of salicylhydroxamic acid and salicylamide from the urine[1]. In the intact animal, salicylhydroxamic acid is therefore partly metabolized to salicylamide. In the present communication, the enzymatic transformation of salicylhydroxamic acid to salicylamide *in vitro* is reported.

Rat liver extract (1 ml.), prepared according to Bray *et al.*[2], was incubated with sodium salicylhydroxamate (1 ml., 0·02 *M* in 0·2 phosphate buffer, *p*H 7·4) at 35° C. for various periods. The reaction was stopped by immersing the mixture for exactly three minutes in boiling water, the coagulated protein thrown down by centrifugation and the supernatant investigated by paper chromatography. A descending method, using Whatman No. 1 filter paper and 1·5 *N* ammonium hydroxide : *n*-butanol (1 : 1) as the solvent system, was employed. With this solvent, good separation of salicylhydroxamic acid, salicylic acid, and salicylamide was obtained with R_F values

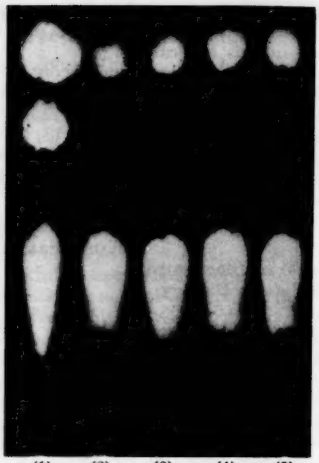

Fig. 1. Chromatogram showing the formation of salicylamide, from salicylhydroxamic acid. 1 : Control spot of salicylhydroxamic acid, salicylic acid and salicylamide; 2, 3, 4 and 5: liver extract and salicylhydroxamic acid incubated for 30, 60, 120 and 240 minutes respectively

for the three compounds approximately 0·24, 0·41 and 0·52 respectively. When viewed under ultra-violet light, salicylic acid and salicylamide show light blue, while salicylhydroxamic acid shows dark blue, fluorescence. The compounds also give characteristic colours when sprayed with ferric ion. In addition, control spots of the above three compounds were always placed on the paper, since the R_F values tended to vary with changes in temperature.

The enzymatic transformation of salicylhydroxamic acid to salicylamide could be definitely established by the identification of the latter on the chromatogram (Fig. 1). Samples of liver extract incubated without salicylhydroxamic acid did not show the presence of salicylamide. There was no hydrolysis of salicylhydroxamic acid to salicylic acid, as indicated by the failure to detect the latter by chromatography. Activity was abolished by placing the enzyme extract for ten minutes in boiling water or by dialysis, but in the latter case was restored by the addition of the concentrated dialysate.

The transformation of salicylhydroxamic acid to salicylamide may be brought about either by a direct enzymatic reduction of the hydroxylamino group or by an exchange reaction in which the hydroxylamino group is exchanged with ammonia or the amide group of glutamine, leading to the formation of salicylamide and hydroxylamine or glutamohydroxamic acid respectively. Virtanen and Berg[3] have reported the enzymatic formation of benzhydroxamic acid from benzoic acid or benzamide and hydroxylamine, and the role of glutamine in certain exchange reactions of this type has been reviewed by Waelsch[4]. In our experiments, no evidence for the formation of hydroxylamine or glutamohydroxamic acid could be obtained. Furthermore, with salicylamide and hydroxylamine or glutamohydroxamic acid as substrates, no formation of salicylhydroxamic acid was observed. On the other hand, while the intermediate formation of hydroxylamines in the enzymatic reduction of aromatic nitro compounds has been demonstrated previously[5], a similar enzymatic reduction of the

hydroxylamino group of hydroxamic acids does not seem to have been reported.

This work is being extended, and a detailed report will be published at a later date.

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Effect of Posterior Pituitary Hormone on the Release of Adrenocorticotrophic Hormone

WE have recently found that the decrease of ascorbic acid concentration of rats' adrenals due to epinephrine is smaller in rats to which pituitrin has been administered and in dehydrated rats than in normal rats[1]. This suggests that the posterior pituitary hormone depresses the adrenal cortical activity. The questions arise, whether the posterior pituitary hormone acts directly on the adrenal or indirectly through the depression of the anterior pituitary secretion, and which fraction of the posterior pituitary hormone, pressor or oxytocic, is responsible for this effect. The present work was undertaken to clarify these points.

Male adult rats were used. Ascorbic acid concentration was determined by the method of Roe and Kuether[2]. Adrenal ascorbic acid concentration of normal rats was 401 ± 16·4 mgm. per cent. When 0·02 mgm. of epinephrine per 100 gm. of body-weight was injected, this concentration decreased to 257 ± 9·8 mgm. per cent; and it remained at a value of 360 ± 22·1 mgm. per cent after injection of the same amount of epinephrine following that of 20 m.u. of pituitrin. When, in place of epinephrine, adrenocorticotrophic hormone (1 u. per 100 gm. body-weight) was administered, the adrenal ascorbic acid concentration was 258 ± 10·9 mgm. per cent, and in this case pituitrin did not alter the value (264 ± 20·1 mgm. per cent). If pituitrin inhibited the adrenocortical secretion directly, it would be expected to suppress the decrease of the ascorbic acid concentration both after epinephrine and after adrenocorticotrophic hormone. As, however, the effect of pituitrin is only seen when epinephrine is used, it may be inferred that the exogenous posterior pituitary hormone inhibits the release of adrenocorticotrophic hormone from the anterior pituitary gland.

Pressor and oxytocic fractions were separately administered to rats, 20 m.u. per 100 gm. body-weight each, and epinephrine (0·02 mgm. per 100 gm.) was injected, while the adrenal ascorbic acid concentration was determined as in the above experiment. The mean value of ascorbic acid was 395 ± 24·2 mgm. per cent for the pressor fraction and 305 ± 15·8 mgm. per cent for the oxytocic fraction. That is, the former fraction alone shows the above effect.

Details of the experiments will be published in the *Japanese Journal of Physiology*.

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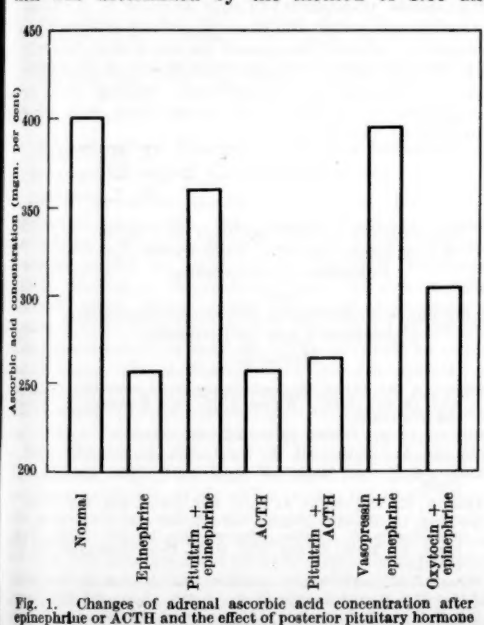

Fig. 1. Changes of adrenal ascorbic acid concentration after epinephrine or ACTH and the effect of posterior pituitary hormone on them

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Oxidative Dissimilation of Glycerol studied with Variants of *Bacillus subtilis*

COMPARING the quantitative aspect of growths of two parent strains of *B. subtilis*, we concluded[1] that, in one of them (S_1^-), the glycerol is oxidized through the tricarboxylic acid cycle, whereas in the other strain (M_2^-) the glycerol, although actively oxidized, does not reach the tricarboxylic acid cycle.

It has already been shown that, in animal tissues[2] and in bacteria[3], the oxidation of glycerol goes through the two following steps:

$$\text{Glycerol} + \text{ATP} \rightarrow \text{glycerol-phosphate} + \text{ADP}$$

$$\text{Glycerol phosphate} \xrightarrow{-2\text{H}} \text{dihydroxyacetone-phosphate or glyceraldehyde-phosphate}$$

This mechanism cannot explain the results we have recently obtained; and we have been able to show the existence of an alternative pathway consisting of the two reactions:

(1) $\text{Glycerol} + \text{DNP}^+ \rightleftharpoons \text{dihydroxyacetone} + \text{DPNH} + \text{H}^+$.

(2) $\text{Dihydroxyacetone} + \text{ATP} \rightarrow \text{dihydroxyacetone-phosphate} + \text{ADP}$.

We have observed activity due to both the enzymes, glyceroldehydrogenase and triokinase, in cell-free

Table 1. Metabolic products of resting cells of the two strains M_2^- and S_1^- tested in Warburg apparatus, each vessel containing in the main cup 2 ml. of bacteria, optical density 3·0 in phosphate buffer *p*H 6·4, *M*/20. The first side-arm has or has not glycerol, the second side-arm 0·3 ml. of 5 *N* sulphuric acid to release carbon dioxide at the end of reaction. All results expressed on the total material by vessel

	Strain M_2^-		Strain S_1^-	
	without glycerol	0·2 ml. *M*/2 glycerol	without glycerol	0·2 ml. *M*/2 glycerol
Oxygen absorbed (μl.)	74	226	30	384
Carbon dioxide released (μl.)	75	88	22	227
Respiratory quotient	1·02	0·08*	0·73	0·58*
Dihydroxyacetone (μ*M*)	traces	12·8	0	0·25
Dihydroxyacetone/oxygen (μ*M*)*	0	1·9	0	~ 0

* Corrected for endorespiration.

extracts of *B. subtilis*. Reaction (1) has been reported recently in *Aerobacter aerogenes*[4] and *Escherichia coli*[5]. Although reaction (2) is not known to occur in bacteria, it is present in animal tissues[6].

In *B. subtilis*, these reactions lead to triosephosphate and eventually to pyruvate and the Krebs cycle; or, by condensation, to hexose derivatives. The difference between the two strains of bacteria is the absence of triokinase in strain M_2^-.

These conclusions have been reached by the successive use of cultures, resting cells and cell-free enzymatic extracts.

In aerated cultures[7] in a medium containing mineral salts and glutamate, the glycerol does not affect the growth of M_2^-, but it enhances actively the growth of S_1^-; with both strains, however, it leads to the formation of reducing substances. With strain M_2^-, 90 per cent of these substances is dihydroxyacetone; S_1^- accumulates less reducing substances, which are a mixture of dihydroxyacetone and acetylmethylcarbinol. The latter is known to arise from the condensation of pyruvate. This finding suggests a metabolic block between glycerol and pyruvate in M_2^-.

Resting cells of M_2^- oxidize glycerol quantitatively to dihydroxyacetone (Table 1); the respiratory quotient is almost nil, and two moles are formed for every mole of oxygen consumed. Cells of strain S_1^- oxidize the glycerol further (*R.Q.* = 0·58) and dihydroxyacetone does not accumulate. Moreover,

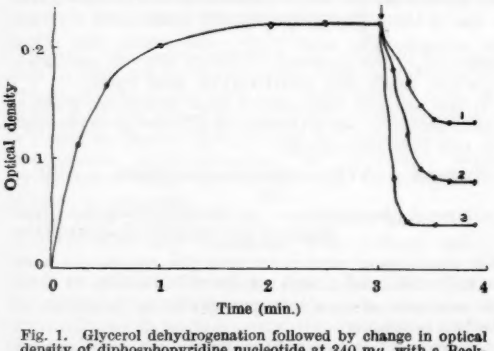

Fig. 1. Glycerol dehydrogenation followed by change in optical density of diphosphopyridine nucleotide at 340 mμ, with a Beckman model *DU* spectrophotometer at room temperature. The reaction mixture at *p*H 8·7 contained: 0·2 ml. cell-free extract; 0·3 ml. water; 1·5 ml. of *M*/10 sodium pyrophosphate; 0·2 ml. of 2·5 *M* glycerol.
At zero time, 0·3 ml. of *M*/1,000 diphosphopyridine nucleotide was added
At the arrow, dihydroxyacetone added: curve 1, 2 μ*M*. curve 2, 5 μ*M*, curve 3, 10 μ*M*. Points are corrected for dilution due to addition of diphosphopyridine nucleotide

Table 2. Test for kinase activities with extracts of two different strains of *B. subtilis*: μl. carbon dioxide released after 30 min. in bicarbonate buffer *p*H 7·7, *M*/30, in Warburg apparatus; gas 5 per cent carbon dioxide in nitrogen. In each vessel, 10 μ*M* adenosine triphosphate, 20 μ*M* dihydroxyacetone, 2 ml. of cell-free extract corresponding to 100 mgm. of lyophilized bacteria, 0·1 ml. of *M*/5 sodium fluoride, 0·1 ml. of *M*/5 magnesium chloride

	M_2^-	S_1^-
Adenosine triphosphate	120	65
Dihydroxyacetone	26	18
Adenosine triphosphate + dihydroxyacetone	118	160

Table 3. Same conditions as in Table 2, except 15 μ*M* adenosine triphosphate. Fructose expressed as fructose 6 phosphate (Roe, ref. 9). Total triose (free + phosphorylated) by conversion to methylglyoxal (to be published elsewhere)

Time (min.)	Alkali-labile phosphate (μ*M*)	Total triose (μ*M*)	Fructose (μ*M*)
0	0	37·5	0
5	2·8	36·0	0
10	4·0	36·2	0·52
30	3·6	30·6	1·98
100	2·4	21·6	2·75

dihydroxyacetone is oxidized by S_1^- and not by M_2^-; this suggests that it is on the oxidative pathway of glycerol.

Cell-free extracts were prepared from 0·5 gm. lyophilized bacteria treated with 10 mgm. lysozyme in 30 ml. of *M*/30 bicarbonate buffer, *p*H 7·7, plus 1 ml. of *M*/2 citrate. The clear supernatant from the centrifugation at 12,000 r.p.m. is precipitated with ammonium sulphate at saturation. The precipitate is redissolved in 10 ml. bicarbonate buffer. The extracts of both strains contain a glyceroldehydrogenase linked with diphosphopyridine nucleotide (Fig. 1).

The fate of the dihydroxyacetone can be explained by the presence of a triokinase in extracts of S_1^-, which is absent in M_2^-. The kinase activity has been followed by the method of Colowick and Kalckar[8] (Table 2) and by the formation of triosephosphate (alkali-labile phosphate) (Table 3).

It is apparent that the triosephosphate is a transient compound, which disappears partly from the mixture. It is probably condensed to a fructose derivative, which is also further transformed, leading to a net disappearance of the total triose (free and phosphorylated) (Table 3).

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Isolation of *n*-Heptadecanoic Acid from Hydrogenated Mutton Fat

In the course of investigations on hydrogenated mutton fat[1], a fraction with saponification equivalent approximating to that of methyl heptadecanoate has been obtained by fractional distillation *in vacuo* in a packed 490 cm. × 3·9 cm. stainless steel column.

Refractionation of an aliquot of this material in a smaller efficient column provided a series of fractions the middle ones of which had saponification equivalents about 284, and these, when converted to acids and submitted to low-temperature crystallization, yielded several grams of a purified acid, of which the saponification equivalent (270·2), melting point (61·2–61·4°) and X-ray analysis (long spacing, 40·8 A.) were all consistent with it being *n*-heptadecanoic acid.

Although other investigators have reported the occurrence of *n*-heptadecanoic acid (margaric acid) in natural fats, Ralston[2] summarizes their work as follows: "All the naturally occurring heptadecanoic acids which have been described and subsequently investigated have been shown to consist of mixtures of palmitic and stearic acids". In the present investigation, however, the characteristics of the fractions preclude the possibility of its being a mixture of palmitic and stearic acids and establish the presence of *n*-heptadecanoic in hydrogenated mutton fat. Further work on the occurrence of *n*-heptadecanoic acid in this and other fats (hydrogenated and unhydrogenated) is in progress and will be published elsewhere.

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Short-range Electrical Forces between Charged Colloid Particles

In a previous communication in *Nature*[1], I suggested that the short-range equilibria which have been proved to occur between montmorillonite lamellæ might be ascribed to electrical attractive forces due to a 'crystalline' layer of interlamellar cations, these forces being balanced by repulsive forces due to adsorbed layers of oriented molecules. The phenomenon is unlikely to be confined to montmorillonite. It is therefore of general interest to consider how such an arrangement might pass into the normal diffuse Gouy layer distribution as the separation between the lamellæ increases.

The first modification to be expected in the 'crystalline' layer of ions is that, as more space becomes available, it should separate into two layers, one attached to each of the facing surfaces. We may reasonably suppose that each of the two layers thus formed will arrange itself so as to make the separation between the ions as great as possible, that is, in a hexagonal lattice. The two lattices of ions will adjust their relative position so as to make the mutual potential energy a minimum. This leads to an attractive force between the lamellæ.

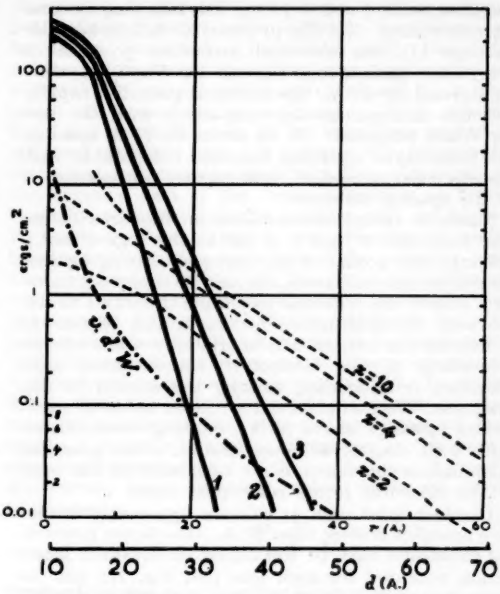

Fig. 1. Potential energy curves for montmorillonite layers. ——, Stern-layer interaction energy (attractive) calculated as described: 1, monovalent cations; 2, divalent; 3, trivalent. — · —, van der Waals energy (attractive) calculated using Verwey and Overbeek's formula (ref. 3), with $A = 5 \times 10^{-13}$. – – –, Gouy-layer interaction energy (repulsive), from Fig. 30 of Verwey and Overbeek's book, with $\kappa = 10^7$. The discontinuous expansion on Norrish's curves (ref. 4) occurs at about 0·27 N, corresponding to $\kappa = 10^{7\cdot1}$

For the sake of simplicity of calculation, square lattices rather than hexagonal were postulated. The mutual potential energy of the two lattices of ions may then be evaluated by Madelung's method[3]. The full expression is complicated, involving a double sum of exponential terms, but the following approximate expression will serve as a basis of discussion:

$$V \simeq \frac{2\sqrt{\sigma^2 ev}}{\varepsilon} \exp\left(-2\pi r\sqrt{\frac{\sigma}{ev}}\right)$$

where e is electronic charge, ε is dielectric constant of medium, σ is surface charge density, v is valency of ions, and r is separation between the two layers of ions. The value of σ is given by the known structural charge of the montmorillonite lamellæ, but some assumptions must be made to fix values for ε and r.

For Fig. 1 these assumptions essentially were: (*a*) each ion is surrounded by a hydration shell one molecule thick; (*b*) the dielectric in these shells is saturated ($\varepsilon = 3$); and (*c*) outside the shells the dielectric is normal liquid water ($\varepsilon = 81$). An increase or a decrease in the extent of the saturated dielectric would result, respectively, in a raising or lowering of these curves without change of shape. A shift of the ionic layers towards or away from the lamellæ would result in a bodily shift of the curves to left or right, respectively, again without change of shape.

The same figure shows some of the curves deduced by Verwey and Overbeek[3] for the Gouy-layer repulsive potential, and the van der Waals attractive

potential (with $A = 5 \times 10^{-12}$). The following features are noteworthy: (1) Up to about 30 A. interlamellar spacings (d), the electrical attractive potential is everywhere greater than the van der Waals potential. (2) Beyond 30–45 A., the electrical potential rapidly becomes unimportant in comparison with the van der Waals potential. (3) At about 20–25 A. spacing, the Gouy-layer repulsion becomes comparable with the electrical attraction, and rapidly outbalances it as the spacing increases.

Norrish's recent observations on montmorillonite gels[4] have shown that it is just in this region that a discontinuity occurs in the curve of spacing against electrolyte concentration. It may be supposed, therefore, that if the potential minimum described in my previous communication[1] occurs in this region—as it does for the sodium–montmorillonite–water system—lowering of the electrolyte concentration may eliminate it altogether, causing the system to disintegrate. Norrish observed a further series of equilibrium spacings above 35 A., showing a continuous shift with electrolyte concentration; the potential minimum in this region is not explicable on the basis of the electrical forces considered here.

Divalent ions[4] such as calcium apparently do not give spacings greater than 20 A. One factor preventing expansion may be the higher electrostatic interaction potential for such ions (see Fig. 1); but the phenomenon is a complex one, and other possible factors involved are: (*a*) the increased radius of saturation of the dielectric; (*b*) the influence of the ions on the energy of sorption of water; and (*c*) their lower degree of dissociation.

It may appear that there is a contradiction involved in postulating simultaneous action of the electrical forces considered here, and of Gouy-layer repulsion, since a layer of ions cannot be both crystalline and diffused. However, at very small separations most of the ions are forced into the Stern layer, only a few 'floating' freely in the interlamellar space. It is the interaction of the Stern layer ions that gives rise to the attractive potential.

A fuller account of this theory will appear elsewhere. I am indebted to Dr. P. M. Grundy and Mr. G. M. Jolly for advice on the mathematical aspects of this work.

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X-Ray and Differential Thermal Studies of some Indian Montmorillonites

It is well known that members of the montmorillonite group may be classified into a number of subgroups which differ in isomorphous substitution, having varying proportions of different cations[1]. Theoretically, a continuous substitution is possible. But although a wide range of substitution is known in clay minerals, a continuous series has not yet been found.

X-ray and differential thermal studies of some Indian bentonites and soils have yielded interesting results in this connexion. The samples studied are bentonites from (i) Kashmir, (ii) Nimlinadi and (iii) Barme, and black cotton soils from (iv) Satara and (v) Indore.

The X-ray pattern of the clay fraction ($< 2\mu$) of these samples in the glycerol-treated form shows the basal spacing 17·7 A., which agrees with that of standard glycerol-montmorillonite[2]. Only sample (ii) shows, in addition to montmorillonite lines, two others at 7·1 A. and 3·5 A., indicating the presence of kaolinite.

The base exchange capacities of samples (i), (ii) and (iii) are 100, 50 and 90 m.equiv./100 gm. respectively. The lower base exchange capacity of sample (ii) compared to montmorillonite is evidently due to the presence of kaolinite.

The differential thermal curve of sample (i), showing endothermic peaks at 200°, 680° and 880° C., agrees with the standard curve of montmorillonite, except for the exothermic peak at 1,000° C., instead of the usual peak at 950° C. This is possibly due to the high magnesium substitution in the octahedral layer. The chemical analysis is: H_2O, 8·4; SiO_2, 63·18; Al_2O_3, 25·26; Fe_2O_3, trace; MgO, 4·15 per cent.

Differential thermal curves of the other four samples show some deviation from the standard for montmorillonite. The first endothermic peaks, for samples (ii) to (v), occur close to 150° C.; but the second ones corresponding to loss of hydroxyl appear at about 570° C., which is lower by about 100 deg. than that of montmorillonite. The 570° C. peak is close to that of nontronite, which has the same peak near 500° C.[3,4]. The exothermic peak lies between 900° and 950° C., as in montmorillonite; but the endothermic peak corresponding to the final breakdown of the lattice, almost invariably present in montmorillonite, is absent. The differential thermal curve of sample (ii) does not indicate the presence of kaolinite.

All the samples reported on here thus belong to the montmorillonite group on the basis of X-ray data; but differential thermal analysis reveals significant deviations, and indicates that the samples (ii), (iii), (iv) and (v) constitute a subgroup intermediate between montmorillonite and nontronite. This probably means a proportionately smaller amount of iron in the lattice than in nontronite. Complete chemical analysis of the samples after removal of free iron oxide is being carried out in order to verify the above assumption.

Two nontronite samples from (vi) Garfield, Washington, and (vii) Sandy Ridge, North Carolina, have also been analysed to study the features distinguishing the present subgroup from nontronite. They show the same basal spacing, namely, 17·7 A. The exothermic peak in both appears at 850° C., which is characteristic of nontronite. The characteristic endothermic peak was found to be at 500° C. in (vi) and 570° C. in (vii). The curve obtained with (vi) agrees with that of standard nontronite. The OH-binding energy in sample (vii) appears to be definitely greater than in standard nontronite, and corresponds to that of the subgroup formed by samples (ii), (iii), (iv) and (v); but its exothermic peak retains the characteristics of the typical nontronite.

The above information, therefore, suggests that samples (ii), (iii), (iv), (v) and (vi) form a more or less continuous link in the montmorillonite – nontronite series.

We are indebted to Prof. S. N. Bose for his many suggestions. Thanks are also due to the Assam Oil

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Heat Transfer in Pulsating Flow

When pulsations are imposed on a flowing fluid, it may normally be expected that heat transfer to or from it would be changed because the pulsations would alter the thickness of the boundary layer and hence the thermal resistance. In the laminar region, this view is also supported by the fact shown by Richardson[1] that the velocity profile for pulsating flow is steeper near the wall than for smooth flow. It follows from a consideration of the Reynolds analogy that the heat transfer should increase under such conditions. A similar process might occur for turbulent flow also, but the equations are too cumbersome for analytical solution.

Experimental information about the process, however, is meagre and sometimes conflicting. In the turbulent region, Martinelli *et al.*[2,3] and Marchant[4] found no difference in heat transfer between steady unidirectional flow and pulsating flow, but West and Taylor[5] reported an increase of 60–70 per cent. In the laminar region, Marchant[4] noted a slight increase, whereas Morris[6] and Webb[7] found no change. All these investigations were carried out at low pulsation frequencies by heating flowing water. Working with oil, Linke[8] found an increase in heat transfer of up to 4 times in the laminar region and up to 1·35 times in the turbulent region. In air, Stanton *et al.*[9] found no difference between a static and a vibrating finned engine-cylinder, whereas Kubanskii[10] obtained an increase of 50 per cent at acoustic frequencies. Andreas[11] advocated the mechanical vibration of the entire heat exchanger to improve heat transfer.

We have carried out investigations under the auspices of the Council for Scientific and Industrial Research, New Delhi, on the heat transfer to pulsating air. These investigations have been carried out by the external heating, by steam, of air at or near atmospheric pressure, flowing in a horizontal pipe of 1 in. inside diameter and 6 ft. 10 in. effective heating length. The heat transfer coefficients were measured first with steady unidirectional flow and then with pulsations imposed on the flow by means of a poppet valve operating in the path of the air. The wave-form and amplitude were measured by an instrument based on an idea of Schweitzer[12]. Reynolds number was varied from 5,000 to 35,000 and frequency of pressure pulsations from 5 to 33 c./s. The experiments were repeated with different wave-forms and amplitudes.

The Reynolds and Nusselt numbers were calculated at the mean temperature of the air, and the velocity used was that obtained by dividing the total volume flow by the cross-sectional area of the pipe. It was found that the Nusselt number changed up to about 30 per cent in a rather uneven but defined manner under different conditions of frequency, amplitude, wave-form and Reynolds number. In general, the change was negative below a certain frequency and positive above it, in the range of frequencies investigated. This critical frequency was a function of the wave-form and to a lesser extent of the Reynolds number. The magnitude of the change increased slightly with Reynolds number, the negative part of the curve increasing at lower Reynolds numbers and the positive part at higher Reynolds numbers. Only a negligible change could be detected when the amplitude of the pulsation was very low, thus corroborating the negative results of Stanton[9]. With higher amplitudes, the change was not directly proportional to the amplitude but depended on a function which combined the frequency, amplitude and Reynolds number. The exact nature of this function is now being investigated. It seems likely that not only the total magnitude of the pressure amplitude but also the steepness of the wave (or the rate of change of pressure in the wave) plays an important part in the mechanism of forced convective heat transfer under pulsating flow conditions.

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Ageing of Quartz Crystal Vibrators

It is probable that in the field of use of quartz crystal vibrators there are no requirements more exacting than those imposed on the quartz vibrator which is used to control the time-keeping of a quartz clock. The British Post Office has had considerable experience in fabricating 100 kc./s. quartz vibrators and incorporating them in suitable oscillator circuits to maintain clocks or frequency standards. It is the general experience that these oscillators have a slow frequency change even after several months of uninterrupted operation. This change is extremely small, being of the order of one part in 10^9 a day for a good clock to one part in 10^{11} for the best clock. Recent tests have shown that the frequency-change or 'ageing' can be reduced by using the crystal vibrator at a temperature which is lower than the normal 50° C.

Fig. 1 shows the results of some tests on a 100 kc./s. *GT*-cut quartz crystal operating at two different temperatures, one within a few millidegrees of a nominal 50° C. and the other of a nominal − 10 ° C.

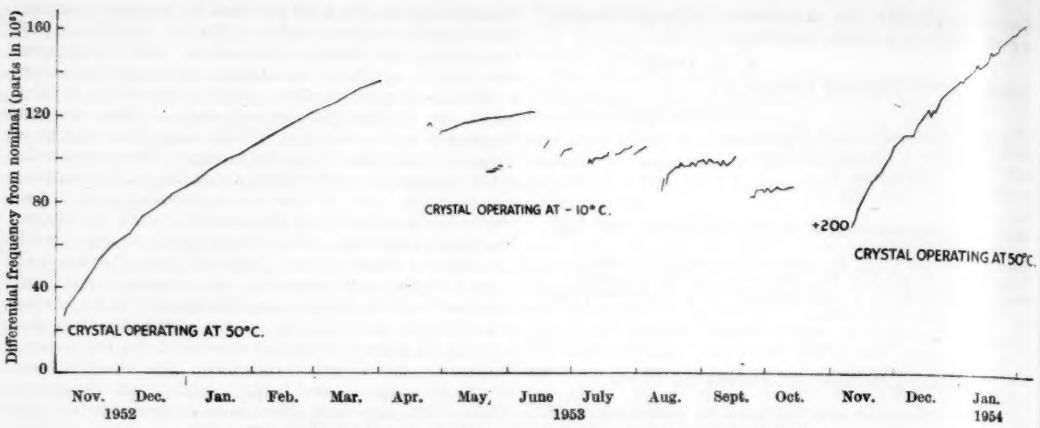

Fig. 1. *GT*-cut quartz resonators. Performance curves for crystal No. 5423

It will be seen that the ageing rates were of the order of:

50 parts in 10^{10} a day at 50° C.
10 parts in 10^{10} a day at − 10° C., and
80 parts in 10^{10} a day when operated again at 50° C.

The crystal used in these tests was gold-plated and was mounted in a clamp in an evacuated copper container. No satisfactory explanation of its ageing or of the reduction of ageing at the lower temperature is known.

A somewhat novel method was used for obtaining the stable − 10° C. condition. The crystal is normally housed in an oven maintained at 50° C. by a bridge-controlled unit. The temperature at which such an arrangement controls depends upon making the bridge balance at the desired temperature and ensuring that the ambient temperature does not approach too closely the desired operating temperature. For the cold tests, the control bridge was made to balance at − 10° C. and the ambient was reduced to − 20° C. by putting the oven in a domestic refrigerator of the deep-freeze type. Some slight difficulties were experienced when the leads from the oscillator to the crystal iced up, and though these were fairly readily cleared, they account for the intermittent nature of the − 10° C. curve.

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Dollis Hill, London, N.W.2. April 29.

Cadmium in Sea-water

Although cadmium has been detected in a number of marine animals in amounts ranging from 0·03 to 11 mgm. per kgm. of the dried organism[1,2], its presence in the sea has not so far been established except by inference[3]. Thus Baidet *et al.*[4], who were able to identify spectrographically fourteen trace metals in a concentrate from 60 l. of sea-water from Roscoff (Brittany), were not able to detect cadmium. Noddack and Noddack[2] consider that the concentration of cadmium in the sea is less than 0·5 μgm./l.

In the present investigation, cadmium was extracted from 1-litre samples of sea-water from the Irish Sea by means of a chloroform solution of dithizone in the presence of cyanide at *p*H 8·8. The cadmium in the extracts was determined spectrophotometrically by a modification of Saltzman's[5] dithizone method (detection limit 0·006 μgm. cadmium).

The unequivocal detection of cadmium was carried out by evaporation of the dithizone extracts on spectrographically pure calcium carbonate (cf. Wark[6]). The products were examined spectrographically by means of a d.c. arc taking 5·5 amp., between pure graphite electrodes. Blank determinations revealed the absence of cadmium in the reagents. In all the spectrograms of sea-water samples the *raies ultimes* of cadmium at 2288·018 A. and 2265·017 A. were strong, and in some a further line at 3261·057 A. was visible. No other elements could be detected in the dithizone extracts. Tests on known amounts of cadmium showed that the 2288·018 A. line was just visible when 5 mμgm. of cadmium was present. This is a considerably greater sensitivity than can be attained by means of the copper spark method[7], or using sodium fluoride as a carrier[8]. Five samples of surface water from the Irish Sea contained amounts of cadmium ranging from 0·032 to 0·075 μgm./kgm. (mean 0·055 ± 0·012 μgm./kgm. or 0·49 μgm.-atoms/ton). This is lower than the concentrations of either zinc or mercury in the sea (*c.* 80[9] and 1·5[10] μgm.-atoms/ton respectively) and is somewhat less than was predicted by Buljan[11].

Further work is proceeding on the seasonal variation of cadmium in the sea and on its concentration by marine algae.

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March 19.

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Succinoxidase Activity of the Flight Muscles of the Wasp, *Sceliphron cementarium*

In insects, succinoxidase activity has been studied in the milkweed bug[1], in the embryonic cells of the grasshopper *Melanoplus differentialis*[2], in the thoracic muscles of the American cockroach *Periplaneta americana*[3], and in the thoracic muscles of the woodroach *Leucophaea maderae*[4]. Harvey and Beck[3] reported a sex difference in the thoracic muscles of the American cockroach, the males showing three times as much activity as the females. This difference was confirmed by McShan *et al.*[4], who also showed that in the woodroach the male and female thoracic muscles have approximately equivalent succinoxidase activity (see Table 1).

Table 1. Succinoxidase Activity in Insect Thoracic Muscles, after Various Authors

Insect	Average Q_{O_2} values	Author
Periplaneta americana ♂	275	Harvey and Beck, 1953
" " ♀	167	Kramer and McShan (unpublished MS.)
" " ♂	38·1	
Leucophaea maderae ♂	156	McShan *et al.*, 1954
" " ♀	153	
Sceliphron cementarium ♀	128	Present paper

In the latter paper it was pointed out that a much higher concentration of succinate (0·20 *M*) is required for optimum activity of the succinoxidase system of woodroach muscle than for this system in mammalian tissues such as rat liver, which requires only 0·05 *M* succinate[5]. Harvey and Beck[3] found 0·11 *M* succinate optimum for American cockroach muscle. These results suggest that tissues such as roach muscle, which are high in succinoxidase activity, require higher concentrations of succinate for maximum activity than do tissues comparatively low in succinoxidase activity.

With this in mind a study of succinoxidase in the indirect flight muscles of the wasp, *Sceliphron cementarium*, was undertaken, using identical concentrations of reagents and co-factors worked out by McShan *et al.* for the woodroach. Individual wasps (these were all females collecting mud from the margin of an excavation pool) were brought in from the field during late June, dissected, remnants of the gut and tracheal tubes were cleaned away and the large indirect flight muscles were removed. The tissue was weighed, placed in ground-glass homogenizing tubes contained in an ice bath, and homogenized within 8-10 minutes after the wasps were killed. Sufficient water was added to give a 2·5 per cent homogenate.

The enzyme determinations were made by use of the conventional Warburg apparatus. Runs were made using 0·05 ml., 0·1 ml. and 0·15 ml. of homogenate together with the required co-factors and reagents as worked out for woodroach muscle. The final concentrations of co-factors and reagents used in the flasks were 0·2 *M* succinate; 0·05 *M* phosphate buffer *p*H 7·3; $1·6 \times 10^{-3}$ *M* each of calcium and aluminium chlorides; and 2×10^{-5} *M* cytochrome *c*. Sufficient water was added to each flask to give a total volume of 3·0 ml. Flasks were placed in the bath at 38° C., ten minutes were allowed for equilibration, and readings of oxygen consumption were taken at ten-minute intervals for forty minutes. The average value for the number of ten-minute periods, during which oxygen consumption was constant, was used as a basis for calculating the Q_{O_2} values.

Table 2. Oxygen Uptake in cu.mm. for 0·05, 0·1 and 0·15 ml. of Wasp Muscle Homogenate

Run	Amount of tissue homogenate in ml.			
	0·05	0·1	0·15	Q_{O_2}
1	6·5	14·15	20·3	105
2	7·9	17·9	24·8	130
3	9·8	18·9	26·8	147
Average	8·1	17·0	24·0	128

The results of these runs are shown in Table 2. As indicated in Fig. 1, the average oxygen consumption for three wasps, each taken from the field and run on three successive days, gave almost perfect linearity from 0·05 ml., 0·1 ml. and 0·15 ml. of tissue homogenate. The average dry weight of this muscle on the basis of three wasps was 30·6 per cent, and using this dry weight for all calculations, the average Q_{O_2} for the three runs was 128.

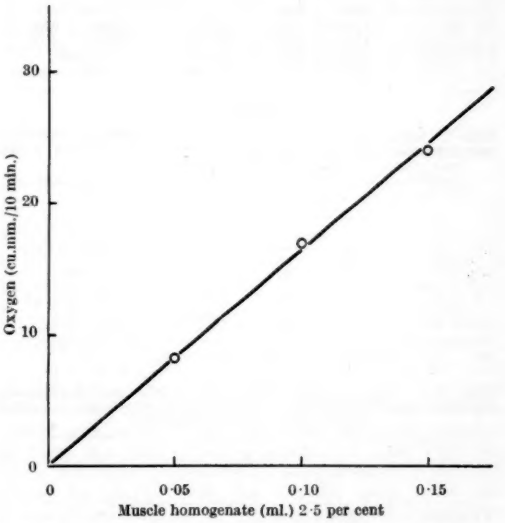

Fig. 1. Relationship between amount of wasp muscle reacting and average amount of oxygen consumed per 10 min.

It is apparent that optimum conditions for the determination of succinoxidase activity of the indirect flight muscles of the wasp *Sceliphron cementarium* are the same as those reported previously for woodroach thoracic muscle.

I am indebted to Prof. W. H. McShan for assistance with this study.

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Feb. 9.

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Thermal Reactions of Kenya Cattle vaccinated with Lapinized Rinderpest Virus

Many workers[1] have recorded thermal reactions in cattle following vaccination with lapinized rinderpest virus. In Kenya, thermal reactions are notable by their absence in vaccinated zebu, high- and low-grade European-zebu crosses and pure-bred European cattle[2]. In an attempt to clarify the position, an analysis of 5,295 morning temperatures from 444 cattle, including 113 uninoculated controls, was made. The cattle had been used for the testing of batches of lapinized rinderpest virus vaccine between August 30, 1950, and March 10, 1952. All the vaccinated cattle were found to be immune on challenge with virulent virus and all the control cattle proved to be susceptible.

Table 1. Fifth Day Post-inoculation: the Difference between the Temperatures of Vaccinated and Control Cattle which were Housed Together

	$\bar{x} \pm t_{05}\, s_{\bar{x}}$		P
	$\bar{x}$	t	
Control	100·7 ± 0·09		
1 : 10	101·0 ± 0·10	2·308*	<0·05 >0·01
1 : 2,000	101·0 ± 0·12	2·333*	<0·05 >0·01
1 : 4,000	100·8 ± 0·10	0·929	>0·05
1 : 10,000	100·8 ± 0·10	0·769	>0·05

* Significant

Table 2. Sixth Day Post-inoculation: the Difference between the Temperatures of Vaccinated and Control Cattle which were Housed Together

	$\bar{x} \pm t_{05}\, s_{\bar{x}}$		P
	$\bar{x}$	t	
Control	100·6 ± 0·08		
1 : 10	101·0 ± 0·11	2·857†	<0·01
1 : 2,000	101·2 ± 0·13	3·667†	<0·001
1 : 4,000	101·0 ± 0·12	2·429*	<0·05 >0·01
1 : 10,000	101·1 ± 0·10	3·846†	<0·001

* Significant † Highly significant.

Table 3. Seventh Day Post-inoculation: the Difference between the Temperatures of Vaccinated and Control Cattle which were Housed Together

	$\bar{x} \pm t_{05}\, s_{\bar{x}}$		P
	$\bar{x}$	t	
Control	100·6 ± 0·09		
1 : 10	100·8 ± 0·10	1·429	>0·05
1 : 2,000	101·3 ± 0·14	3·762†	<0·001
1 : 4,000	100·9 ± 0·10	2·538*	<0·05 >0·01
1 : 10,000	101·0 ± 0·09	3·077†	<0·01 >0·001

* Significant † Highly significant.

Pertinent data are recorded in Tables 1, 2 and 3. The normal morning bovine rectal temperature at the Rinderpest Isolation Laboratory, Kabete, altitude 6,000 ft., and situated between the 65° F. and 70° F. isotherms, was 100·63° F. (± 0·02° F.) with a coefficient of variation of 1 per cent. The temperature curves of the uninoculated and the vaccinated cattle were identical except on the fifth, sixth and seventh days after inoculation. Over this period the temperatures of the vaccinated animals were significantly higher and, as might be expected, the rise began earlier in the cattle which had received the higher concentration of the virus.

The thermal reaction in cattle, after inoculation with caprinized rinderpest virus, occurs on the fifth–seventh days, and it is suggested that a similar syndrome is associated with the administration of lapinized rinderpest virus, except that the reaction cannot be detected by an examination of a few animals. Thus the dictum 'no reaction no immunity' might be held to be fulfilled with this, as with other types of live rinderpest virus vaccination.

It is noteworthy that the mean rectal temperature of grade steers was 100·63° F. (± 0·02° F.). This figure is lower than that reported from Europe[3] and India[4].

I am indebted to the Director of Veterinary Services, Kenya, for permission to publish these findings.

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Feb. 24.

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A Polarographic Method for the determination of the Gamma Isomer of Benzene Hexachloride in Cattle Dips

One serious practical difficulty in the use of benzene hexachloride in cattle dips is that of loss of biological efficiency.

The accurate biological testing of dip-washes is a difficult and lengthy process; but recently Downing *et al.*[1] have shown that loss of biological efficiency is accompanied by a corresponding diminution in the ratio gamma isomer/total benzene hexachloride. These workers used partition chromatography of the extracted benzene hexachloride for the determination of the gamma isomer; but because this method is not well adapted to routine examination of large numbers of samples, a polarographic approach was attempted.

Under the conditions of high altitude and ambient temperature prevailing at these laboratories, Dragt's[2] method is inconvenient due to the use of acetone as a solvent, and the method of Ingam and Southern[3] gave unsatisfactory results in our hands when applied to the analysis of gamma concentrates containing relatively high concentrations of the interfering[2] heptachlorocyclohexane.

The following method was found satisfactory. A Cambridge voltamoscope was used at sensitivity 1/20 and moderate damping, the midpoint of the galvo-oscillations being measured.

The following reagents were used: concentrated hydrochloric acid; 95 per cent ethyl alcohol, redistilled from silver nitrate to remove reducible impurities; 0·5 per cent gelatin solution, prepared daily; 0·2 *M* potassium chloride.

To a volume of the well-mixed sample, containing about 40 mgm. gamma isomer, add one-quarter its volume concentrated hydrochloric acid. Filter, and wash the solids with cold distilled water until free from acid. Dry in a desiccator over solid sodium hydroxide, and when dry, extract the solids with purified alcohol in a Soxhlet. Dilute the extract to 100 ml. with alcohol. Pipette a 25-ml. aliquot into a 50-ml. volumetric flask, add 0·5 ml. 0·5 per cent gelatin and dilute to volume with 0·2 *M* potassium chloride. Filter a portion into a polarographic cell, de-gas with hydrogen or nitrogen, and record the wave between − 0·5 V. and − 1·8 V. versus saturated

calomel electrode at 30° C. (This temperature was used because of the high ambient temperature.) To measure the wave-height draw a straight line through the curve at − 0·6 V. and − 1·0 V. and extend to meet the − 1·3 V. perpendicular. The vertical distance between this intersection and the wave at − 1·7 V. gives the wave-height.

The gamma isomer concentration is read from a standard curve prepared using pure gamma isomer. A convenient range for this curve is 3–15 mgm. gamma isomer, this yielding a straight line, not passing through the origin.

Further aliquots of the alcohol extract are analysed for total benzene hexachloride by normal dehydrohalogenation methods, and the ratio gamma isomer/total benzene hexachloride calculated.

The method of extracting the benzene hexachloride is essentially that of Hitchcock *et al.*, as briefly described by Mackerras[4], while the empirical method of wave measurement is similar to that of Dragt[3].

I wish to thank the Chief Veterinary Research Officer, Tanganyika, for the constant interest he has shown during the development of this method, and the Director of Veterinary Services, Tanganyika, for permission to publish this account.

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March 2.

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Isolation from the Lower Respiratory Tract of Chickens of Bacteria administered by Mouth

It is generally assumed that bacteria ingested in food or water do not enter the trachea but that all of them pass down the œsophagus. One interesting observation in this respect was made by White and Minett[1], who noted that when calves were fed milk containing *Mycobacterium tuberculosis* primary lesions of tuberculosis were sometimes found in the lungs, indicating that some of the bacteria administered may have been aspirated into the lungs. More direct evidence that this may occur was obtained as a result of some experiments that were designed to trace the route by which *Salmonella gallinarum* enters the body following its administration to chickens by mouth.

In the initial studies large numbers of *Salm. gallinarum* bacteria were mixed in a commercial mash and fed to chickens which were then killed at different times and selected organs cultured. *Salm. gallinarum* was isolated from the lungs of an unexpectedly high proportion of chickens, in some after an interval of time so short as to preclude them having reached this organ via the intestine.

In view of this, four groups each consisting of fifteen nine-week-old chickens were taken. The first group was fasted for 12 hr. and then fed on a commercial mash into which had been mixed an 18-hr. broth culture of *Salm. gallinarum*, 1 ml. per 10 gm. of mash. The culture contained approximately 50×10^7 bacteria per ml. Water was withheld from the second group for 12 hr. This group was then provided with drinking water, every 10 ml. of which contained 1 ml. of the broth culture. 1 ml. of the culture was placed carefully into the mouth of the chickens in the third group by means of a pipette. A similar amount of culture was given to the fourth group by means of a pipette introduced via the mouth into the œsophagus, care being taken to avoid touching the epiglottis.

The chickens were killed ¾ hr. later by dislocation of the neck, and, at the same time, a pair of strong artery forceps was fixed, through the skin, around the upper portion of the trachea so as to occlude its orifice. A post-mortem examination was then carried out using aseptic precautions. Cultures were made from the mucous membrane of the lower end of the trachea on to deoxycholate–citrate agar[2] and a portion about 1 in. long of this part of the trachea placed in a tube of selenite-F medium[3]. Most of the left lung was removed, ground in sterile sand and one loopful of this streaked on to a plate of deoxycholate–citrate agar; the remainder was placed in a tube of selenite-F medium. The selenite-F cultures were incubated at 37° C. for 24 hr. and plated on to deoxycholate–citrate agar. All plates of the latter medium were incubated at 37° C. for 24 hr. and then examined for the presence of *Salm. gallinarum*. The results are shown in Table 1.

Table 1

Method of administering *Salm. gallinarum*	No. of 15 chickens in which *Salm. gallinarum* was isolated from		
	Trachea	Lung	Trachea and/or lung
In food	4	10	12
In drinking water	4	5	7
Into mouth by pipette	9	3	10
Into œsophagus by pipette	0	0	0

Salm. gallinarum was not isolated from the lower respiratory tract of any of the fifteen chickens to which it was given by means of a pipette into the œsophagus. Quite different results were obtained when it was administered by the other three methods, *Salm. gallinarum* being recovered from the trachea or lungs of a considerable proportion of these chickens. It is noteworthy that *Salm. gallinarum* was isolated more frequently from the trachea than from the lungs of the chickens to which it was given by pipette into the mouth (9–3); the reverse was true in the case of the chickens fed infected food (4–10).

Salm. gallinarum was only isolated by direct culture in one case, from the trachea of a chicken given this organism by pipette into the mouth. The other isolations were made through selenite-F medium. It is therefore probable that infection via the lower respiratory tract would be of little significance under natural conditions since chickens would not be exposed to such large numbers of bacteria. However, it is a point to be borne in mind when the production of experimental infections is under consideration.

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Feb. 26.

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Tape for Microsectioning of Very Large, Hard or Brittle Specimens

During the last decades of the nineteenth century several methods were introduced to make sectioning possible of such hard or brittle specimens as eggs, containing large amounts of yolk granules, and arthropods with a skeleton of chitin, where the usual paraffin technique failed.

The section-surface of the paraffin block was coated with a thin film of collodion, paraffin, shellac or mastic, and this procedure was repeated after each section made.

Sometimes such methods are still used, in case of emergency; but they are rather difficult to handle and very often quite unsatisfactory.

Against these methods a ribbon of cellulose tape applied over and firmly pressed to the section surface of a paraffin block or of a specimen in the freezing microtome serves admirably for the purpose.

The section is very firmly attached to the sticky substance of the tape, and hence it cannot be wrinkled or shattered by the sectioning. Sections ranging from one micron or less in thickness to several hundred microns are always quite even. In fact, there is no trouble at all in sectioning specimens from which it would seem to be impossible to get useful sections with any other method. (For example, with the tape method whole adult mice have been sectioned (for autoradiograms) in a freezing microtome without fixation or decalcification.)

The sticky substance on the tape is soluble in benzene, toluene and xylene. Hence, the paraffin (of paraffin sections attached to tape) cannot be dissolved in the usual manner in benzene. However, the paraffin can be slowly removed in warm amyl alcohol, the sticky substance being insoluble in alcohols.

The cellulose tape is stainable, therefore drops of stain solutions should be applied to the section only. Glycerol can be used as mounting medium.

However, from a histological point of view it is preferable to transfer the section to a glass slide by the following technique.

(1) Mount the section on the tape, with the section turned upwards, on a glass slide with small strips of tape (applied so that they do not cover any part of the section itself). This is in order to get the section on a horizontal level.

(2) Spread out, using a glass rod, ½ per cent solution of celloidin in absolute alcohol and ether, equal parts, to a thin layer all over the section (but not all over the tape). Let the celloidin film perfectly dry in the air.

(3) Transfer the preparation to benzene (or toluene or xylene) in a shallow wide glass dish (for example, a Petri dish) and leave it until (within a few minutes) the collodion film, including the section, can easily be loosened from the tape. Leave the section for a while in benzene, so that all the remaining sticky substance is dissolved.

(4) Smear a cleaned slide rather liberally with egg albumen all over, dip the slide, with the smeared surface upwards, in the benzene and float the section, the previous 'tape-side' down, to the slide. Mount the section on the slide and press and blot it dry with a piece of filter paper.

(5) Transfer, at once, the slide to absolute alcohol and ether in equal parts, and leave it until the collodion is dissolved. In my experience the section is now firmly cemented to the slide.

(6) Transfer the slide to 95 per cent alcohol. Now the section can be treated as an ordinary deparaffinized section fixed on a glass slide, thus suitably stained and finally mounted in the usual manner.

Frozen sections fixed on tape must either be dried (for example, for autoradiograms of water-soluble radioactive substances) or, from a histological point of view, better, of course, be transferred from water to alcohol and to absolute alcohol before the collodion film is applied as described above.

The section can (for photographic registration of radioactivity) be attached directly to the photographic film without egg albumen, but preferably after moistening the film.

The tape method may be useful whenever the ordinary micro-sectioning technique fails and also for cutting very thin sections and for reconstructions. Sections made with the tape technique are even and are uniform from the beginning and never require any deforming treatment.

Series of sections can be made by cutting sections, border to border, on one and the same ribbon of tape, which is held rolled up on each side of the paraffin block above the level of the microtome knife during the sectioning, so that the knife does not cut the tape itself.

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Zoological Nomenclature

Notice is hereby given that, as from November 11, 1954, the International Commission on Zoological Nomenclature will start to vote on the following cases involving the possible use of its plenary powers for the purposes specified against each entry. Full particulars of these cases were published on May 11, 1954, in the *Bulletin of Zoological Nomenclature* in Parts 6, 7 and 8 of Volume 9. (1) *immigrans* Sturtevant, 1921 (*Drosophila*) (Cl. Insecta, Order Diptera), validation of; (2) *pruni* Geoffroy, 1762 (*Aphis*) (Cl. Insecta, Order Hemiptera), validation of; (3) *Lachnus* Burmeister, 1835, and *Cinara* Westwood, 1835 (Cl. Insecta, Order Hemiptera), designation of type species for; (4) *Stentor* Oken, 1815 (Cl. Ciliophera), validation of, and designation of type species for; (5) *Melanargia* Meigen, 1828 (Cl. Insecta, Order Lepidoptera), validation of; (6) Geoffroy, 1762, *Hist. abrégée*; validation of six generic names (*Stratiomys*, *Stomoxys*, *Volucella*, *Nemotelus*, *Scatopse*, *Bibio*) in the Order Diptera, published in; (7) *Palmatotriton* Smith, 1945 (Cl. Amphibia), suppression of; (8) *Ammonites mammillatus* Schlotheim, 1813, designation of neotype for, and *Douvilleiceras* de Grossouvre, 1893, designation of type species for (Cl. Cephalopoda, Order Ammonoidea).

Comments on the above cases should be sent to me as soon as possible.

Francis Hemming
(Secretary to the International
Commission on Zoological Nomenclature)

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, July 5—Saturday, July 10

SOCIETY FOR APPLIED BACTERIOLOGY (in the Agriculture Lecture Room, The University Department of Agriculture, 10 George Square, Edinburgh)—Annual Meeting and Summer Conference.

Tuesday, July 6

ASSOCIATION FOR THE STUDY OF ANIMAL BEHAVIOUR (in the Psychology Department, Birkbeck College, Malet Street, London, W.C.1), at 10.30 a.m.—Scientific Papers on "Some Aspects of Social Behaviour".

Wednesday, July 7

PHYSICAL SOCIETY (at the Royal Institution, 21 Albemarle Street, London, W.1), at 4.30 p.m.—Prof. J. A. Wheeler (Princeton University): "Fields and Particles"*.

ROYAL METEOROLOGICAL SOCIETY (at the National Institute of Oceanography, Wormley, near Godalming, Surrey)—Summer Meeting*.

Wednesday, July 7—Saturday, July 10

INSTITUTE OF PHYSICS, NON-DESTRUCTIVE TESTING GROUP (at Chancellor's Hall, The University, Birmingham)—Summer Meeting.

Thursday, July 8

At 9.15 a.m.—Annual General Meeting.

Wednesday, July 7—Wednesday, July 14

INSTITUTION OF PRODUCTION ENGINEERS (in the National Hall, Olympia, London, W.14)—Production Exhibition and Conference.

Wednesday, July 7—Friday, July 16

COMMONWEALTH INSTITUTE OF ENTOMOLOGY (in the Large Chemistry Lecture Theatre, Chemistry Department, Royal College of Science, Imperial Institute Road, London, S.W.7)—Sixth Commonwealth Entomological Conference*.

Thursday, July 8—Monday, July 12

BRITISH INSTITUTION OF RADIO ENGINEERS (at the University of Oxford)—Convention on "Industrial Electronics".

Friday, July 9

PHYSICAL SOCIETY (at the Royal Institution, 21 Albemarle Street, London, W.1), at 4.30 p.m.—Prof. E. Amaldi (Rome): "The European Organization for Nuclear Research"*.

Friday, July 9—Saturday, July 10

PHYSICAL SOCIETY, OPTICAL GROUP (at the University, Reading)—Summer Meeting.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT, Grade B (with a good degree and able to teach inorganic and physical chemistry to degree standard) IN CHEMISTRY—The Secretary, Norwood Technical College, Knights Hill, London, S.E.27 (July 8).

AGRICULTURAL ECONOMIST and an ASSISTANT AGRICULTURAL ECONOMIST (with a degree in economics, agricultural economics or agriculture); and a LECTURER or ASSISTANT LECTURER IN AGRICULTURAL ECONOMICS—The Registrar, University College of Wales, Aberystwyth (July 9).

ASSISTANT LECTURER IN PHYSICS—The Registrar, University College of North Staffordshire (July 10).

LECTURER IN PHYSIOLOGY—The Registrar, King's College (University of London), Strand, London, W.C.2 (July 10).

LECTURER (with a good honours degree in mathematics and sound teaching experience) IN THE MATHEMATICS DEPARTMENT—The Registrar, Technical College, Sunderland (July 10).

PHYSICAL CHEMIST (preferably with experience in ultra-violet absorption spectroscopy), to apply spectroscopic techniques to problems of organic chemistry and biology—The Secretary, Chester Beatty Research Institute, Institute of Cancer Research, Royal Cancer Hospital, Fulham Road, London, S.W.3 (July 10).

PHYSICISTS and ENGINEERS (Scientific Officer and Experimental Officer grade) at the Ministry of Supply Radar Research Establishment, Malvern, Worcs, for the design and testing of high temperature electronic components for use under severe vibration and climatic conditions—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.161/54A (July 10).

SCIENTIFIC OFFICER (with first- or second-class honours degree in chemistry or equivalent, with special emphasis on inorganic chemistry, and an interest in, and a sound knowledge of, mineral analysis), in the Mineral Resources Division, Colonial Geological Surveys, for work in laboratories at Imperial Institute Building, London, S.W.7, on the analysis and examination of minerals and their products, rocks, fuels, etc., and the development of methods of analysis—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting F.382/54A (July 10).

SCIENTIFIC OFFICER (with first- or second-class honours degree or equivalent in physics, electrical engineering or mathematics, and preferably with research experience in electronics or aerodynamics, or flying experience with the R.A.F.), at the Royal Aircraft Establishment Experimental Unit, Martlesham Heath, for work on all weather and rapid landing problems of civil and military aircraft, involving co-operation in design and assessment of full scale flight experiments in marshalling, blind approach and landing, and liaison with civil and military aviation authorities—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.160/54A (July 10).

SENIOR LECTURER (preferably with an interest in the physics of the ionosphere) IN PHYSICS, at University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (July 10).

ASSISTANT ANALYST (with either a university degree or A.R.I.C., and preferably with experience in the analysis of food and drugs)—The County Medical Officer of Health, East Cliff County Offices, Preston, quoting "Assistant Analyst" (July 12).

SCIENTIFIC OFFICER (with an honours degree in plant physiology) IN THE IRRIGATION SECTION—The Secretary, National Vegetable Research Station, Wellesbourne, Warwick (July 12).

LECTURER IN MORAL PHILOSOPHY—The Secretary, The University, Aberdeen (July 13).

ASSISTANT LECTURER AND DEMONSTRATOR (graduate in science or technology, with subsidiary qualifications in biochemistry or physics) to lecture on the pure sciences on which leather technology is based, and to supervise laboratory work—The Registrar, National Leathersellers College, 176 Tower Bridge Road, London, S.E.1 (July 16).

RESEARCH DEMONSTRATOR IN PHYSICS—The Registrar, University College, Leicester (July 16).

RESEARCH OFFICER (with a university honours degree in science with mathematics as major subject, preferably with physics also to a high standard or equivalent qualifications) in the Division of Radiophysics, Commonwealth Scientific and Industrial Research Organization, Sydney, N.S.W., Australia, to organize and take charge of a group which will be responsible for the analysis of the results of cloud seeding experiments, of rainfall and other singularities, and the possible effects of meteoritic dust, and allied problems—The Chief Scientific Liaison Officer, Africa House, Kingsway, London, W.C.2, quoting 780/123 (July 16).

RESEARCH SCHOLAR (graduate in science or technology, or other suitable qualification), to carry out research on some problems of interest to the leather industry, and to take part in teaching—The Registrar, National Leathersellers College, 176 Tower Bridge Road, London, S.E.1 (July 16).

APPLIED GENETICIST (Scientific, Senior Scientific or Principal Scientific Officer grade) to work on the problems of fruit and vegetable breeding in Scotland, and a CROP PHYSIOLOGIST (Scientific, Senior Scientific or Principal Scientific Officer grade), to study effect of environment and climatic complex on horticultural crops in Scotland—The Secretary, Scottish Horticultural Research Institute, Mylnefield, Invergowrie, by Dundee (July 20).

RESEARCH SCHOLAR (with a good honours degree in chemistry)—The Registrar, The University, Reading (July 24).

ASSISTANT LECTURER (with an honours degree in agricultural chemistry or chemistry) IN AGRICULTURAL CHEMISTRY—The Registrar, The University, Reading (July 31).

LECTURER IN THE DEPARTMENT OF BOTANY of the University of Pietermaritzburg—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (July 31).

SENIOR LECTURER IN APPLIED MATHEMATICS at the University of Natal, Durban, a SENIOR LECTURER IN APPLIED MATHEMATICS and a LECTURER IN MATHEMATICS, at the University of Natal, Pietermaritzburg—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (July 31).

SENIOR RESEARCH FELLOW (with research experience in virology) IN THE DEPARTMENT OF MICRO-BIOLOGY, John Curtin School of Medical Research—The Registrar, Australian National University, Box 4, G.P.O., Canberra, A.C.T., Australia (July 31).

ADMINISTRATIVE OFFICER (preferably with technical experience appropriate to an organic chemical laboratory), for duties which will include buying, accounting and laboratory management under the Head of the Department—The Secretary, Dyson Perrins Laboratory (Oxford University), South Parks Road, Oxford.

ALLEN AND HANBURYS RESEARCH FELLOWSHIP tenable in the Department of Pharmacology—The Clerk to the Council, School of Pharmacy, University of London, 17 Bloomsbury Square, London, W.C.1.

ASSISTANT (medically qualified, and preferably with experience in bacteriology) for teaching and research—The Secretary, University College Hospital Medical School, University Street, London, W.C.1.

BIOCHEMIST (preferably with experience in hospital biochemistry)—The Secretary, Stepney Group Hospital Management Committee, Raine Street, Wapping, London, E.1.

CROP ECOLOGIST (with either a good honours degree in botany with postgraduate training in agriculture or agricultural botany and a sound grasp of statistics, particularly those concerning crop sampling, or a degree in mathematics with experience of statistical techniques and some knowledge of and interest in biometry or botany) in the Department of Soil and Land-Use Survey, Gold Coast Local Civil Service, to collect field data for the various crops grown on different soils—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.79/13/03.

DEMONSTRATOR IN BOTANY—The Registrar, Wye College (University of London), near Ashford, Kent.

DESIGN ENGINEERS (with recognized engineering apprenticeship with A.M.I.Mech.E. or equivalent, and experience of special purpose machinery or chemical plant design) in the Department of Atomic Energy, to undertake duties of project engineers, including design and layout of special plant and equipment—The Department of Atomic Energy, Industrial Group Headquarters, Risley, Warrington, quoting 614.

GRADUATE CHEMIST or METALLURGIST for work which involves laboratory and field trial studies of the causes and prevention of corrosion of iron and steel and the application of results obtained to practical causes—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting "Corrosion".

HONOURS GRADUATE (qualified bacteriologist, or chemist with a sound bacteriological training) IN THE BACTERIOLOGY DEPARTMENT,

for work on disinfection involving a study of methods of evaluating chemical sterilizers—The Secretary, National Institute for Research in Dairying (University of Reading), Shinfield, near Reading, quoting 54/6.

Lecturer (with a good honours degree, teaching experience, and preferably other postgraduate, industrial or research experience) in Physical Chemistry at Leeds College of Technology—The Chief Education Officer, Education Offices, Leeds 1.

Master or Mistress to teach biology throughout the school up to university entrance standard—The Headmaster, School House, Keswick, Cumberland.

Mineralogist Chemist (with a first- or good second-class honours degree in geology or chemistry, and experience in the analysis, identification, study, etc., of mineral species) in Tanganyika (Her Majesty's Colonial Service)—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting BCD.105/8/04.

Petroleum Chemist (graduate of a recognized university in chemistry or chemical engineering), to supervise analyses and tests of petroleum products used in aircraft, such as gasoline, jet fuels, engine lubricants, coolants and hydraulic oils—National Research Council, Scientific Liaison Office, Africa House, Kingsway, London, W.C.2.

Professor (with a degree in chemistry, and teaching experience, preferably in a medical school) of General Chemistry, at the Royal College of Medicine, Baghdad—A.S. 12, Almack House, 26–28 King Street, London, S.W.1, quoting A.12/ME/546/IRQ.

Research Assistants in the Departments of Botany and Zoology, Chemistry, Mathematics, Metallurgy (including Geology) and Physics—The Secretary, Sir John Cass College, Jewry Street, Aldgate, London, E.C.3.

Scientific Officers (with a first- or second-class honours degree or equivalent, in mathematics or physics), in London and the provinces, for operational research on a wide variety of problems, under the direction of the Scientific Adviser to the Air Ministry—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.285/52/A.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Colonial Development Corporation. Annual Report and Statement of Accounts for year to 31.12.53. Pp. v+50. (London: H.M. Stationery Office, 1954.) 2*s*. net. [105

Institute of Personnel Management. Occasional Papers No. 5: The Worker in Modern Industry. By Nigel Balchin. Pp. 14. (London: Institute of Personnel Management, 1954.) 2*s*. [105

Leeds City Museums. Guide Book to the Abbey House Museum. Pp. 12 (2 plates). (Leeds: Leeds City Museums, 1954.) 6*d*. [105

Department of Scientific and Industrial Research. Report of the Chemistry Research Board, with the Report of the Director of the Chemical Research Laboratory, for the year 1953. Pp. iv+73. (London: H.M. Stationery Office, 1954.) 2*s*. 6*d*. net. [105

Air Ministry: Meteorological Office. Professional Notes No. 110: On the Accuracy of Contour Charts in Forecasting Upper Winds. By R. Murray. Pp. 12. (M.O. 524j.) (London: H.M. Stationery Office, 1954.) 6*d*. net. [105

The Registrar General's Statistical Review of England and Wales for the year 1949. Supplement on Hospital In-Patient Statistics. Pp. xii+486. (London: H.M. Stationery Office, 1954.) 15*s*. net. [105

British Iron and Steel Research Association. Annual Report, 1953. Pp. 140+18 plates. (London: British Iron and Steel Research Association, 1954.) [105

Air Ministry: Meteorological Office. Professional Notes No. 109: Radar Echoes From and Turbulence Within Cumulus and Cumulonimbus Clouds. By R. F. Jones. (M.O. 524i.) Pp. 20. (London: H.M. Stationery Office, 1945.) 9*d*. net. [105

Cambridge University Educational Film Council. Seventh Report, March 1954. Pp. 8. (Cambridge: Cambridge University Educational Film Council, 1954.) [105

Department of Scientific and Industrial Research. National Physical Laboratory. Report for the year 1953. Pp. viii+73+4 plates. (London: H.M. Stationery Office, 1954.) 3*s*. net. [105

Department of Scientific and Industrial Research. Report of the Pest Infestation Research Board, with the Report of the Director of Pest Infestation Research, for the year 1953. Pp. iv+46+4 plates. (London: H.M. Stationery Office, 1954.) 2*s*. net. [105

Ovaltine Research Laboratories, Annual Report, 1953. Pp. 8. (London: A. Wander, Ltd., 1954.) [105

Bulletin of the British Museum (Natural History). Entomology. Vol. 3, No. 7: Some Sawflies of the European Alps and the Mediterranean Region (Hymenoptera: Symphyta). By Robert B. Benson. Pp. 267–296. (London: British Museum (Natural History), 1954.) 6*s*. [115

The Registrar General's Decennial Supplement, England and Wales, 1951. Occupational Mortality, Part 1: Deaths in 1951 in certain broad groups of occupations related to population figures derived from the 1951 Census one per cent sample tables. Pp. iv+76. (London: H.M. Stationery Office, 1954.) 7*s*. 6*d*. net. [115

Other Countries

Sheth Bholabhai Jeshingbhai Institute of Learning and Research. Research Series 43: Planetary Tables. Vol. 1: Tables of Mercury. By Prof. Harihar P. Bhatt. Pp. x+20+18 tables. (Ahmedabad: Rasiklal Chhotalal Parikh, B.J. Institute of Learning and Research, 1953.) 2 rupees. [105

Bulletin of the American Museum of Natural History. Vol. 103, Article 5: Oral Incubation in *Tilapia macrocephala*. 1: Embryological Studies. By Evelyn S. Shaw. 2: Experimental Studies. By Evelyn S. Shaw and Lester R. Aronson. Pp. 375–416+plates 35–47. 1.25 dollars. Vol. 103, Article 6: A Revision of *Cyrtoneurina* Giglio-Tos, with notes on Related Genera (Diptera, Muscidae). By Fred M. Snyder. Pp. 417–464. 75 cents. (New York: American Museum of Natural History, 1954.) [105

Fertilizers: Production, Consumption and Trade in European Countries, 1951–1954. Pp. 64. (Paris: Organisation for European Economic Co-operation, 1954.) [105

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United Nations. Demographic Yearbook, 1953. (Fifth issue.) Pp. 442. (New York: United Nations; London: H.M. Stationery Office, 1954.) 6.50 dollars, cloth; 5 dollars, paper; 47*s*. 6*d*., cloth; 37*s*. 6*d*., paper. [105

Berichte des Deutschen Wetterdienstes. Nr. 11: Über starke Niederschläge im Gebeit Taunus-Odenwald. Von Rudolf Aniol. Pp. 16. (Bad Kissingen: Deutschen Wetterdienstes, 1954.) [105

Directory of International Scientific Organisations. Second edition. Pp. 312. (Paris: Unesco; London: H.M. Stationery Office, 1953.) 2.50 dollars; 13*s*. 6*d*.; 650 francs. [145

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Unesco and Its Programme. Nr. 11: European Co-operation in Nuclear Research. Pp. 26. (Paris: Unesco; London: H.M. Stationery Office, 1954.) 1*s*. [145

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Treponematoses: a World Problem. By Dr. T. Guthe and Dr. R. R. Willcox. Pp. 80. (Geneva: World Health Organization; London: H.M. Stationery Office, 1954.) 2 Swiss francs; 3*s*. 6*d*. net; 0.50 dollars. [145

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Murfume Smokes and Atomizing Concentrates. Pp. 8. (Wheathampstead: Murphy Chemical Company, Ltd., 1954.)

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Laboratory Chemicals—Price List (February 1954). (Price List of Chemicals, Nivoc Analytical Reagents, Standard Solutions and Stains.) Pp. 120. (London and Birmingham: W. & J. George and Becker, Ltd., 1954.)

Light's Organic Chemicals—1954 List. Pp. 42. (Colnbrook: L. Light and Co., Ltd., 1954.)

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